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THERMOELECTRICALLY COOLED CLOUD PHYSICS EXPANSION CHAMBER

Final Technical Report

by

Richard J. Buist

January 31, 1977

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Sponsored by

George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Alabama 35812

Contract No.
NAS8-31633

BORG-WARNER THERMOELECTRICS
Wolf & Algonquin Roads
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PREFACE

This report describes the development of the thermoelectric cooling of an expansion chamber for use in cloud physics experimentation. Work was performed at Borg-Warner Thermoelectrics, Des Plaines, Illinois under contract #NAS8-31633 awarded by the George C. Marshall Space Flight Center, Huntsville, Alabama. The contract was administered by C. A. Law, Contracting Officer and B. Elkins, Contracting Officer's Representative.

The author wishes to acknowledge the many significant contributions by Borg-Warner Thermoelectrics personnel: Dr. J. S. Lee in the area of heat sink design, thermal modeling, and acceptance testing; R. W. Duenn who served as Project Manager and Production Manager; B. Peters, L. Shaw, and L. Black in the area of hardware production; F. Smith in quality control; and K. Ryan, Administrative Assistant.

Finally, the author is especially grateful for the many helpful discussions and guidance by G. Barr and J. Moses, Contracting Officer's Technical Representative, of the Marshall Space Flight Center.

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1. SUMMARY

The major objective of this program was to provide means of controlling the temperature of an expansion chamber for use in cloud physics experimentation. The original concept as proposed by MSFC was to attach single stage thermoelectric modules in a close-packed configuration over the entire surface of the chamber.

The pursuance of this program involved four distinct phases of activity and conceptualization. Phase 1 was characterized by the development of a mechanical design, thermal modeling, and computer programming. Initial calculations were based on the approach as outlined in the original MSFC RFP -- that of applying single stage modules directly to the chamber. This approach proved to be marginal requiring utilizing high quality thermoelectric materials, the maximum power budget, and the most optimistic space lab water supply conditions.

Phase 2 added a thermoelectric pre-cooler between the space lab water supply and the heat sinks of the chamber thermoelectric modules. Although greatly improving the system steady-state performance, the cool-down time was not acceptable to MSFC.

Phase 3 eliminated the pre-cooler and replaced the single stage chamber thermoelectrics with multi-stage cascades. The cool down time was enormously improved without sacrificing the steady-state performance improvement made in Phase 2. However, this approach put a large ΔT across the thermoelectrics in contact with the chamber and thereby augmented potential isothermal problems.

It was at this point in the program that BWTE was made aware of a given transient cooling requirement. This requirement was not part of the contract but was of the overall program. Attempts to simulate the desired transient performance led to the conclusion that this condition could not be met under the imposed constraints. A simple calculation from the cooling slope required and the mass of the chamber revealed that a heat extraction rate of 2960 watts from the chamber at -10°C (14°F) was required. The maximum heat extraction rate of even a 5-stage thermoelectric optimized for that temperature using the full 1.5 kw power budget was less than 500 watts.

The fourth and final phase of the program involved a complete change in the scope of effort. A contract modification was made redefining the objectives in a revised statement of work. In general, this involved the design and fabrication of a thermoelectric chiller for use in cooling a liquid reservoir. This removed responsibility for cool down of the chamber, itself, from BWTE.

A subsequent reservoir chiller was designed, fabricated, tested, and delivered to MSFC. An acceptance test was designed complete with a reservoir thermally similar to that anticipated for the end item usage. Test results established the accuracy of the thermal model as well as unit compliance with all specifications as stated in the modified contract. Finally, calculations were made using this thermal model in order to predict the unit performance under various other conditions.

2. INTRODUCTION

Thermoelectrics are finding increased utilization in aerospace applications as a result of characteristics particularly compatible with requirements. Thermoelectrics have the advantage of being able to heat, cool, and modulate temperatures by a simple feed back input current control. Having no moving parts, these control systems are generally lighter, smaller-sized, and are potentially more effective and reliable than competing temperature control systems.

The concept of applying thermoelectrics to cloud chambers was introduced by Dr. Kassner of the University of Missouri-Rolla. Borg-Warner Thermoelectrics (BWTE) supplied the thermoelectric modules and provided some technical assistance for this application. BWTE had and still has reservations about achieving the degree of isothermal precision required over a large set of thermoelectrics. However, BWTE has made every effort to be fully responsive to program requirements even though not formally committed contractually. Indeed, design conceptualization underwent several phases in response to Marshall Space Flight Center's (MSFC) requests even though each concept technically met all contract requirements. The final phase involved a redefinition of the scope of effort and corresponding contract modification. All requirements of the modified contract were met by BWTE.

3. PHASE 1 - MODULES

The initial phase of this program was discussed in detail in the BWTE proposal dated May 28, 1975 submitted in response to MSFC RFP #8-1-5-60-01462. Basically, it involved the thermal/mechanical design of a system for cooling an expansion cloud chamber using single stage thermoelectric modules (see Figures 3.1 and 3.2).

3.1 Mechanical Design

Thermoelectric modules were evenly distributed over the surface of the cloud chamber. On sections 2 and 3, six modules were assumed on each of the 32 flats, or a total of 192 modules per section. Maintaining the same "packing density" of thermoelectrics, 64 modules were placed on each end of the cloud chamber, sections 4 and 5 as well as on the middle section 1. Half modules were used around the viewports and on the cloud chamber ends and were included in the total module count. The total number of modules in the system was, therefore, 576.

3.1.1 Heat Sink Considerations - For maximum isothermal conditions, counterflow aluminum heat sinks were chosen. Three separate heat sinks were considered to cover each of the 32 flats around the periphery of the cloud chamber, one heat sink each on sections 2 and 3, and one on section 1. The water inlet and outlet was provided on each end of the chamber. Additional heat sinks covering the modules on the ends of the chamber were also fed from the water input at the

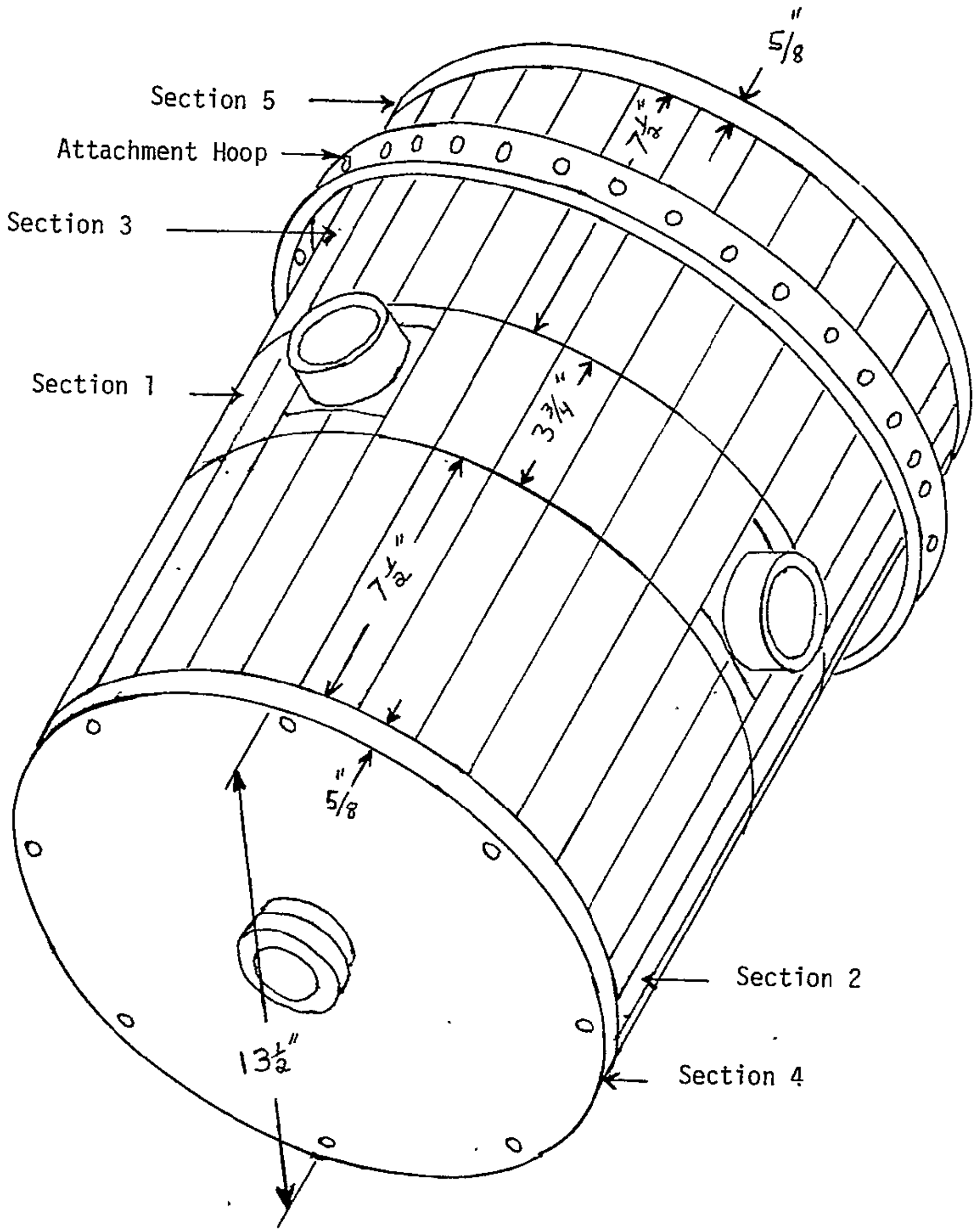


FIGURE 3.1 Expansion Cloud Chamber

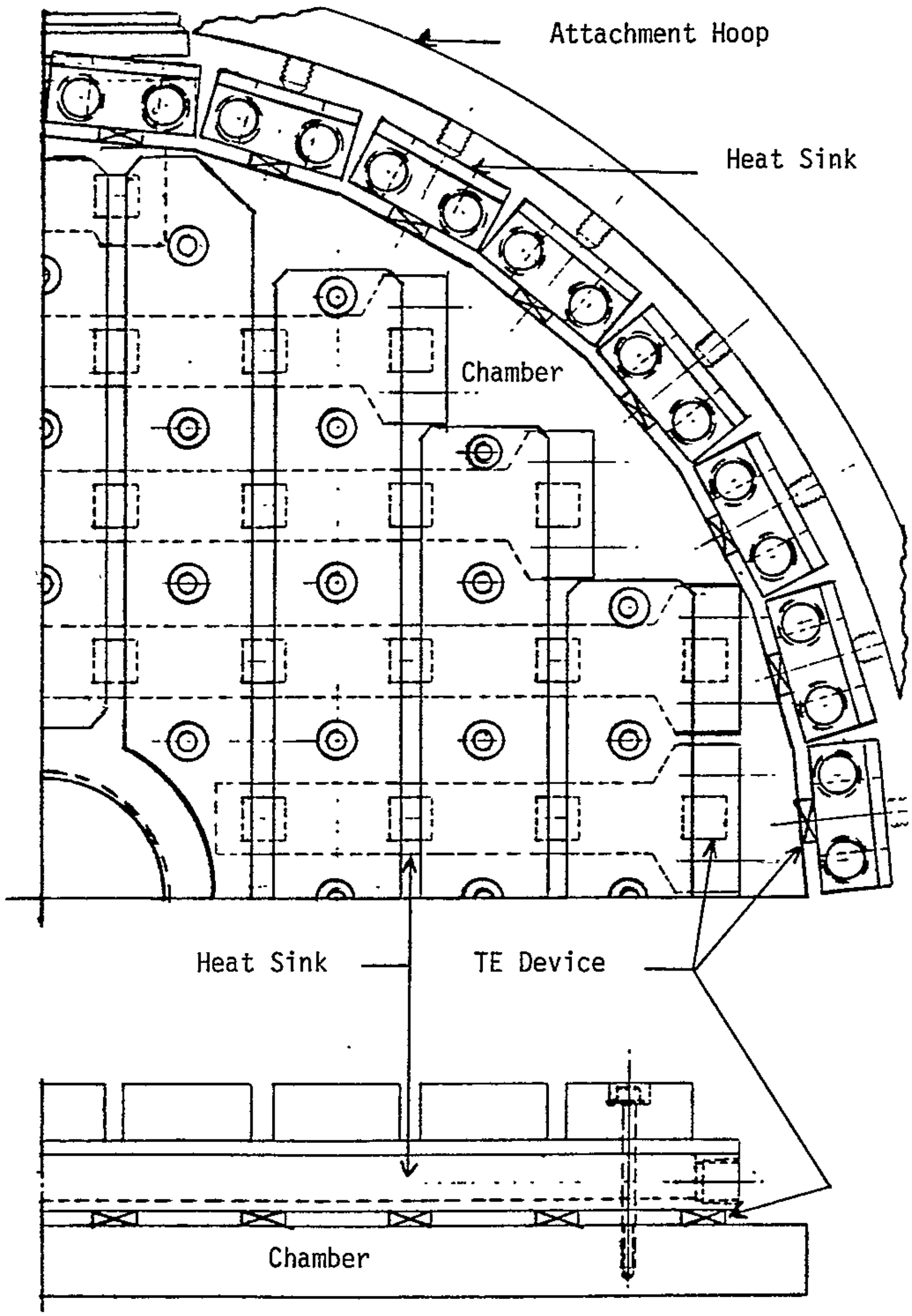


FIGURE 3.2 Method of TE Device Attachment

respective ends. To provide parallel flow equalizing pressure drop and flow rate in each section, a "gas burner type" manifold for the input and output water was provided at each end of the chamber.

3.1.2 Physical Attachment - To minimize the thermal attachment load a "hoop" type compressive mounting system was developed for this application. A series of cylindrical hoops with inside dimensions approximately 1/2" larger than the outside dimension of the heat sinks, drilled and tapped to hold set screws, were provided. A set screw in the hoop was positioned over each heat sink. Tightening the set screws evenly provided balanced clamping forces to each heat sink. Using this system there was no thermal contact between the heat sinks and the cloud chamber, and consequently no attachment heat load. On the ends of the chamber the mounting system is more difficult, so 128 1" long insulated stainless steel screws were provided to mount the heat sinks. With this mounting design concept developed, the initial system thermal analysis and module design was initiated.

3.2 Thermal Design

3.2.1 Requirement Summary

3.2.1.1 Chamber Temperature - The chamber temperature was to be operated at a maximum temperature of 110°F and a minimum of -15°F.

3.2.1.2 Heat Sink - The heat exhausted by the thermo-

electrics was to be dissipated by a heat sink which was, in turn, cooled by a flow of water. The water inlet temperature was 60 to 80°F. The water flow rate was 100-300 lbs/hr.

3.2.1.3 Supply Voltage - The available ranges of supply voltage were 15-22 volts, or 32-40 volts. Maximum system power budget was 1.5 kilowatts.

3.2.1.4 Performance Prediction - The cool down rate and minimum temperature obtainable with the proposed system was to be estimated.

3.2.1.5 Thermal Loads - The thermal load distribution from various sources was to be determined together with a development of techniques to minimize these various thermal loads.

3.2.1.6 Module Design - The optimum number of modules to be series-connected was to be determined. The smallest adequate lead wire size was to be used.

3.2.2 Thermal Load Calculations - Initial calculations of the heat sink water temperature rise at maximum input power indicated a minimum of 20 to 60°F depending on water flow rate. Consequently, equations were developed for each source of thermal load as a function

of the cold chamber temperature, the heat sink temperature, and ambient temperature.

3.2.2.1 Radiation - The view factor of the radiation surfaces was assumed to be 1.0. The emissivity of these surfaces was assumed to be 0.4. The effective emissivity of the two plates was calculated according to equation 3.2.2.1.1:

$$3.2.2.1.1 \qquad \varepsilon = \frac{1}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1} = 0.25$$

where: $\varepsilon_1 = \varepsilon_2 = 0.4$

The equation for the total radiative thermal load on the cold chamber is given in equation 3.2.2.1.2:

$$3.2.2.1.2 \qquad QR = \sigma \varepsilon A_o \ (THHS^4 - TCCH^4)$$

where: $\sigma = 3.659 \times 10^{-11} \frac{\text{watts}}{\text{in}^2 {}^\circ K^4}$

TCCH = Chamber Temperature

THHS = Heat Sink Temperature

A_o = Chamber Outside Area

3.2.2.2 Convection/Conduction - The ambient air pressure for convection/conduction loss calculations was assumed to be 15 psia. The thermal load for this condition was calculated by simply assuming air conduction loss between the plates. It was determined that natural convection losses in this air space were negligible compared with conduction losses. The equation for air conduction loss is given in equation 3.2.2.2.1:

3.2.2.2.1 $QC = \frac{A_o}{L} \kappa_a (THHS - TCCH)$

where: L = Distance Between Plates

κ_a = Thermal Conductivity in Air

3.2.2.3 Windows - The proximity of the windows to the heat sinks was such that the heat sink temperatures were not instrumental in the thermal load due to the windows, i.e. the thermal load due to the windows was a function of the ambient temperature and the chamber temperature. The equation for the heat load due to windows is given in equation 3.2.2.3.1:

3.2.2.3.1 $QW = h A_w (TAMB - TCCH)$

where: $h = 2$ BTU/hr ft^2 °F

$A_w = 169$ in^2

TAMB = Ambient Temperature

3.2.2.4 Lamps - Two 30-watt lamps were assumed with 89% transmission losses. Therefore, the thermal load due to the lamps was 6.6 watts constant for the system.

3.2.2.5 Attachment - The mechanical description formulated in Section 3.1 indicated the usage of 128 one inch long stainless steel #4 machine screws to mount the thermoelectric modules in compression between the heat sinks and chamber on either end of the chamber. The following equation was generated which expresses the heat short or thermal load due to these stainless steel screws:

3.1.2.2.5.1 $QA = N_S \kappa_S \frac{A_s}{L_s} (THHS - TCCH)$

where: N_S = Number of screws

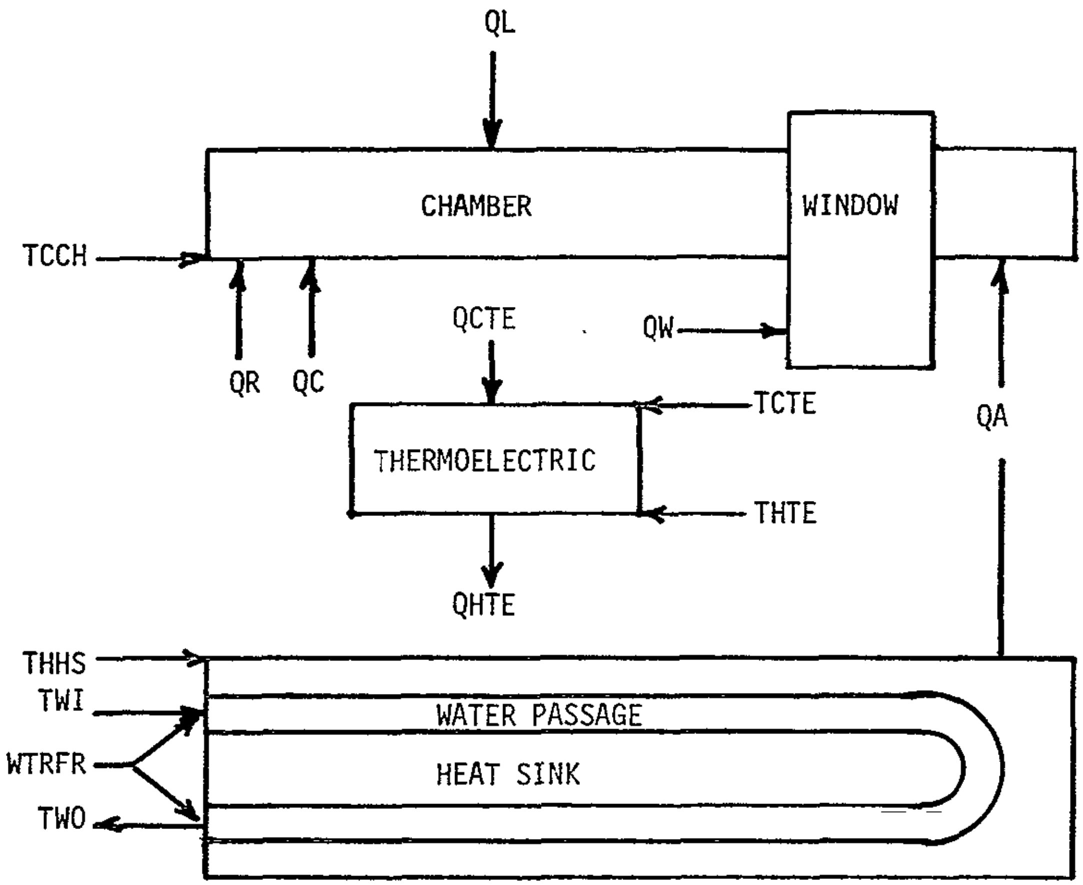
κ_S = Thermal conductivity of screws

A_S = Cross-sectional area of one screw

L_S = Length of screw

3.2.3 Design Model - The mathematical model used for design calculations is shown in Figure 3.2.3.1. Indicated thermal loads were calculated according to the equations developed in Section 3.2.2. The water flow passage was designed to form a single loop to minimize thermal gradients in the heat sinks. A nominal value of 5W/°C/in was assumed for the thermal contact resistance between the modules and mounting surfaces.

Thermal analysis of the system indicated a significant heat sink limitation resulting in a relatively high heat sink temperature rise in the maximum power condition. Consequently, it was discovered that the combination of highest flow rate, 300 lb/hr, and lowest temperature, 60°F, of coolant water together with the optimized application of the highest quality thermoelectric material was required to meet the low temperature specification. The results of the design calculations are given in Table 3.2.3.1:



THERMAL LOADS

QR - Radiation Load
QC - Conduction Load
QL - Lamp Load
QW - Window Load
QA - Attachment Load

TEMPERATURES

TCTE - Cold Side of Thermoelectrics
THTE - Hot Side of Thermoelectrics
TCCH - Chamber

HEAT SINK

TWI - Inlet Water Temperature
TWO - Outlet Water Temperature
WFRFR - Water Flow Rate

HEAT FLUX

QCTE - Heat Pumped by Thermoelectric Module

QHTE - Heat Exhausted by Thermoelectric Module

FIGURE 3.2.3.1 Thermal Design Model

Table 3.2.3.1
THERMOELECTRIC MODULE SYSTEM DESIGN DATA

Mechanical Description

HT SNK (WT*MIN/F)	=	202.00
CHAMBER (WT*MIN/F)	=	255.00
INSD AREA (SQ IN)	=	907.00
OUTSD AREA (SQ IN)	=	1120.00
HEAT SINK EFF	=	0.95
WTR FLW RT (LB/HR)	=	300.00

System Power Conditions

APPLIED VOLTAGE	=	20.0
INITL CURNT (AMPS)	=	90.6
FINAL CURNT (AMPS)	=	74.1
INITL POWER (WATTS)	=	1811.1
FINAL POWER (WATTS)	=	1481.2

Thermoelectric Parameters

NUMBER OF STRINGS	=	18.000
MODULES/STRING	=	32.000
COUPLES/MODULE	=	7.000
T.E. L/A (/CM)	=	7.820
T.E. COP	=	0.216

Thermal Loads (Watts)

RADIATION	=	45.40
CONV/COND	=	193.41
WINDOWS	=	51.52
ATTACHMENT	=	20.42
LAMPS	=	6.60
TOTAL	=	317.42

Temperatures (Deg F)

CHAMBER	=	-14.91
T.E. COLD	=	-15.11
T.E. HOT	=	82.35
HEAT SINK	=	81.29
WATER IN	=	60.00
WATER OUT	=	80.23

3.3 Transient Performance Calculations

A computer simulation program was generated with the constraints outlined in the thermal model shown in Figure 3.2.3.1. The pertinent results are shown in the transient cool down performance curve of Figure 3.3.1. It is observed that the chamber temperature is very nearly at equilibrium within one hour after power turn-on, and is

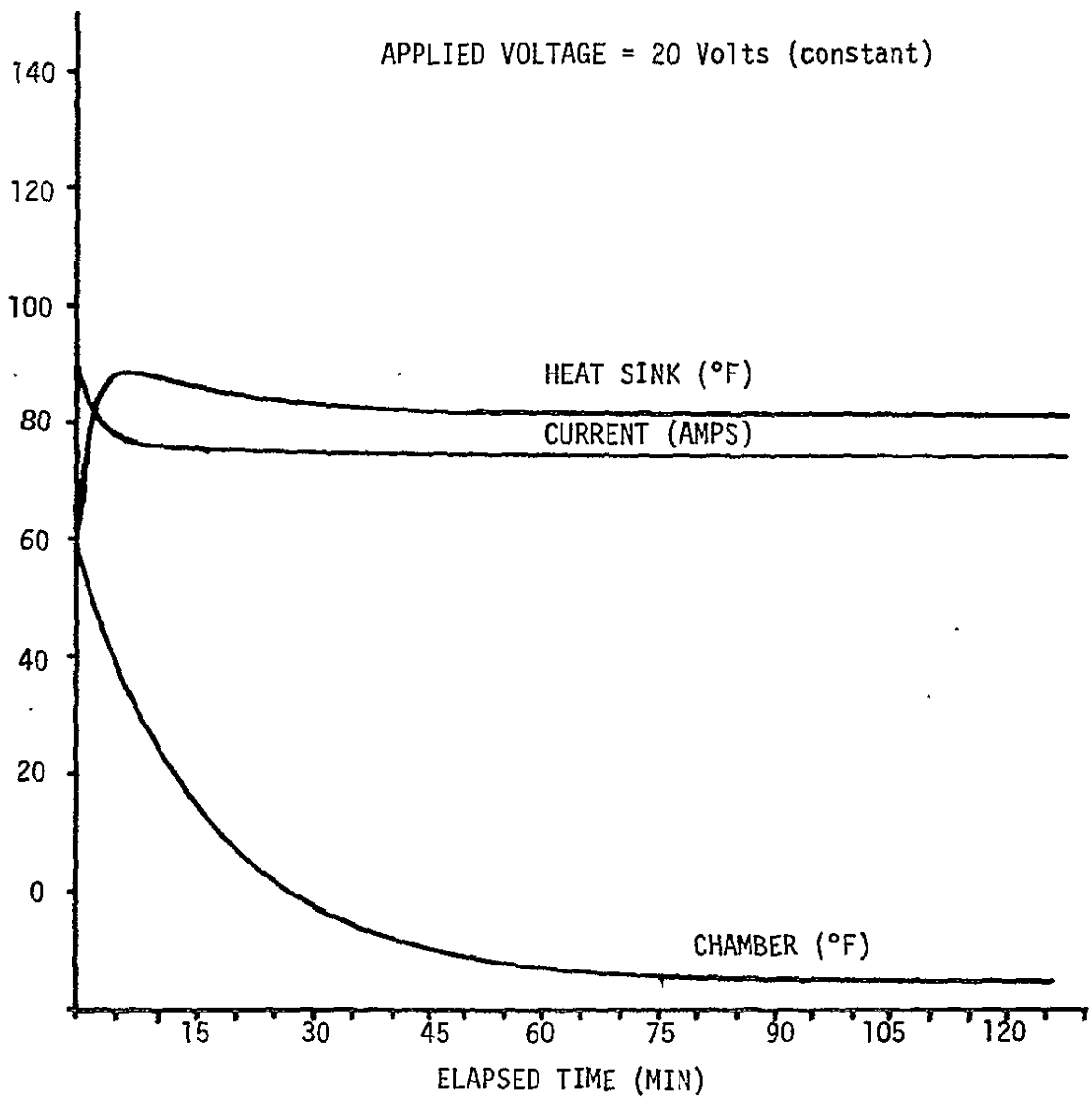


FIGURE 3.3.1 Transient Cool-Down Performance
(Single-Stage TE)

truly at equilibrium within two hours after initial turn-on. Figure 3.3.2 illustrates the build-up of the thermal load components as a function of time after initial power turn-on.

3.4 Conclusions

The concern for the design generated in this initial phase of the contract was that the assumed conditions of 60°F space lab water at 300 lb/hr flow rate and full power budget of 1.5 kw could not be realized simultaneously on a continual basis in practice. Furthermore, concern was expressed by BWTE that the large module ΔT required (97.5°F) would augment thermal variance between modules. Therefore, a pre-cooler concept was introduced to correct these shortcomings and a second phase of the program was initiated.

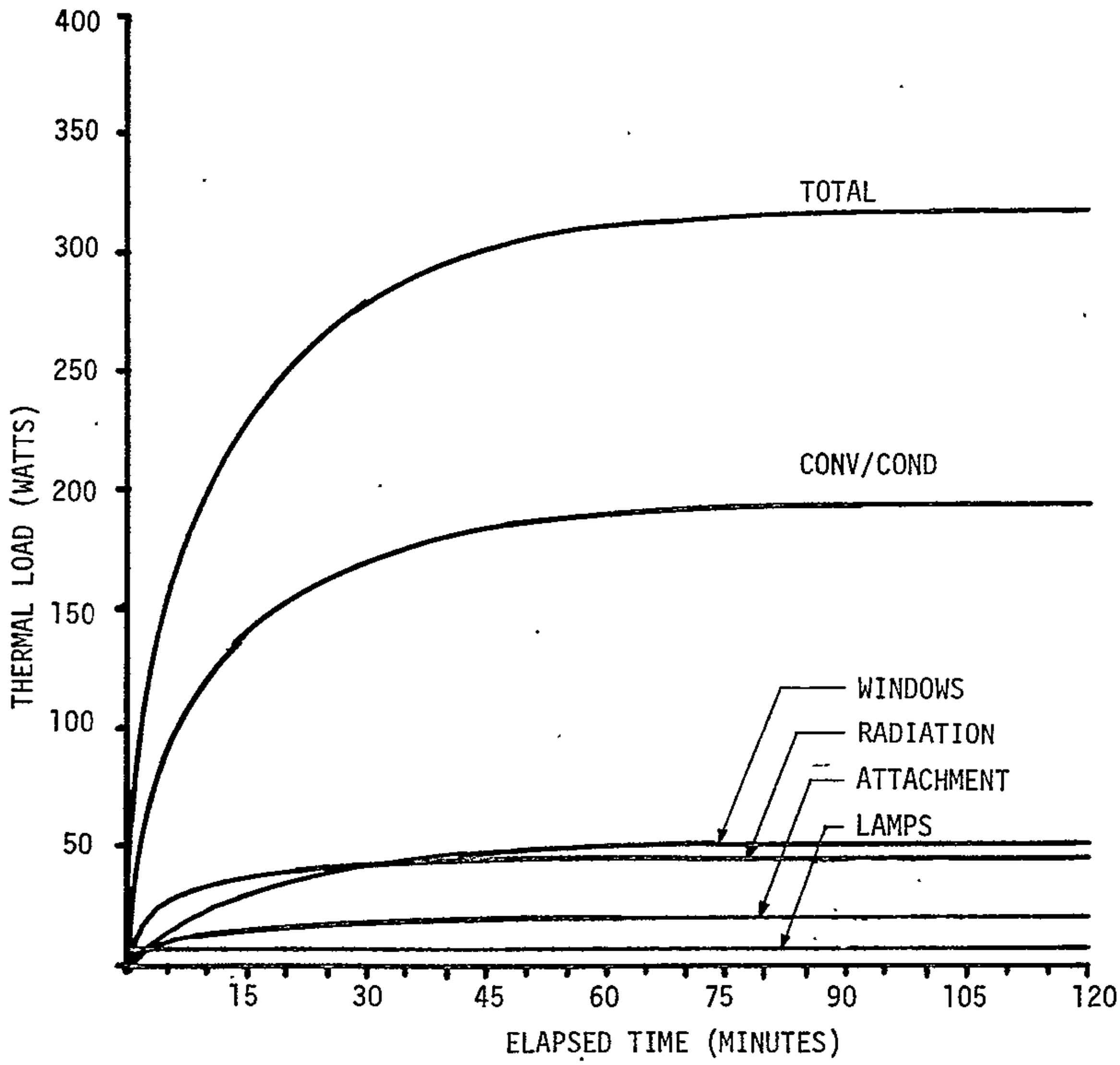


FIGURE 3.3.2 Transient Thermal Loads on Chamber

4. PHASE 2 - PRE-COOLER PLUS MODULES

The concept of pre-cooling the liquid coolant in the cloud chamber heat sinks was studied. The advantage of this approach was that the heat sink temperature could be maintained closer to the desired temperature in the cloud chamber using the thermoelectrics on the cloud chamber as trimmer coolers rather than primary coolers. This would result in much closer temperature control of the cloud chamber.

The thermal model is shown in Figure 4.1. In order to eliminate as many variables as possible the space lab flow rate-specific heat product was set to 200 BTU/hr°F by MSFC. The effect of chamber inlet temperature on the design of the pre-cooler and chamber thermoelectrics is shown in Figure 4.2. It is clear from this figure that the optimum chamber heat sink inlet temperature was approximately 20°F. Therefore, all subsequent calculations were made using this value.

Calculations were made on the effect of heat sink effectiveness on the system design. It was clear from those results that neither the chamber heat sink nor the pre-cooler effectiveness had a very dramatic effect on the input required. Therefore, the most reasonable combination of these values was chosen for subsequent calculations, namely 0.80 for both heat sinks.

The predicted performance of the pre-cooler/chamber system is shown in Figure 4.3. Since the size and weight of the pre-cooler were unknown, several cases were generated to illustrate the effect of the

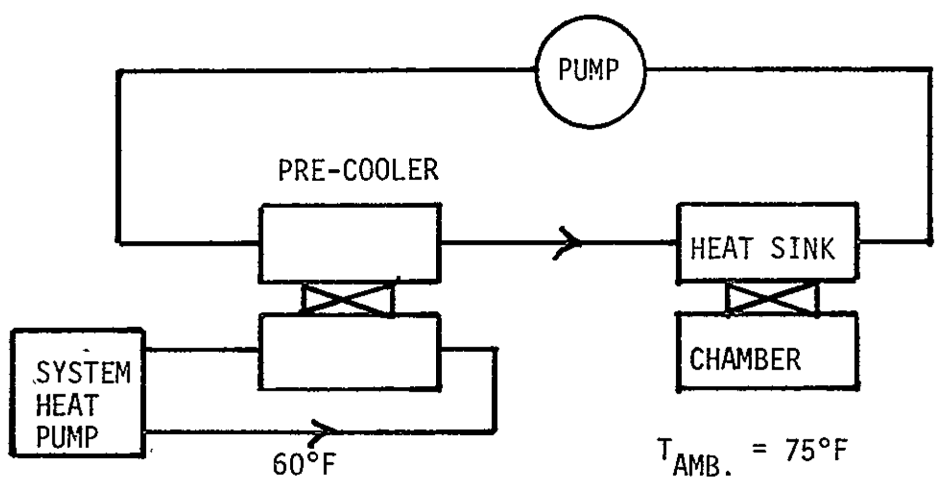


FIGURE 4.1 Model for Pre-Cooler/Chamber System

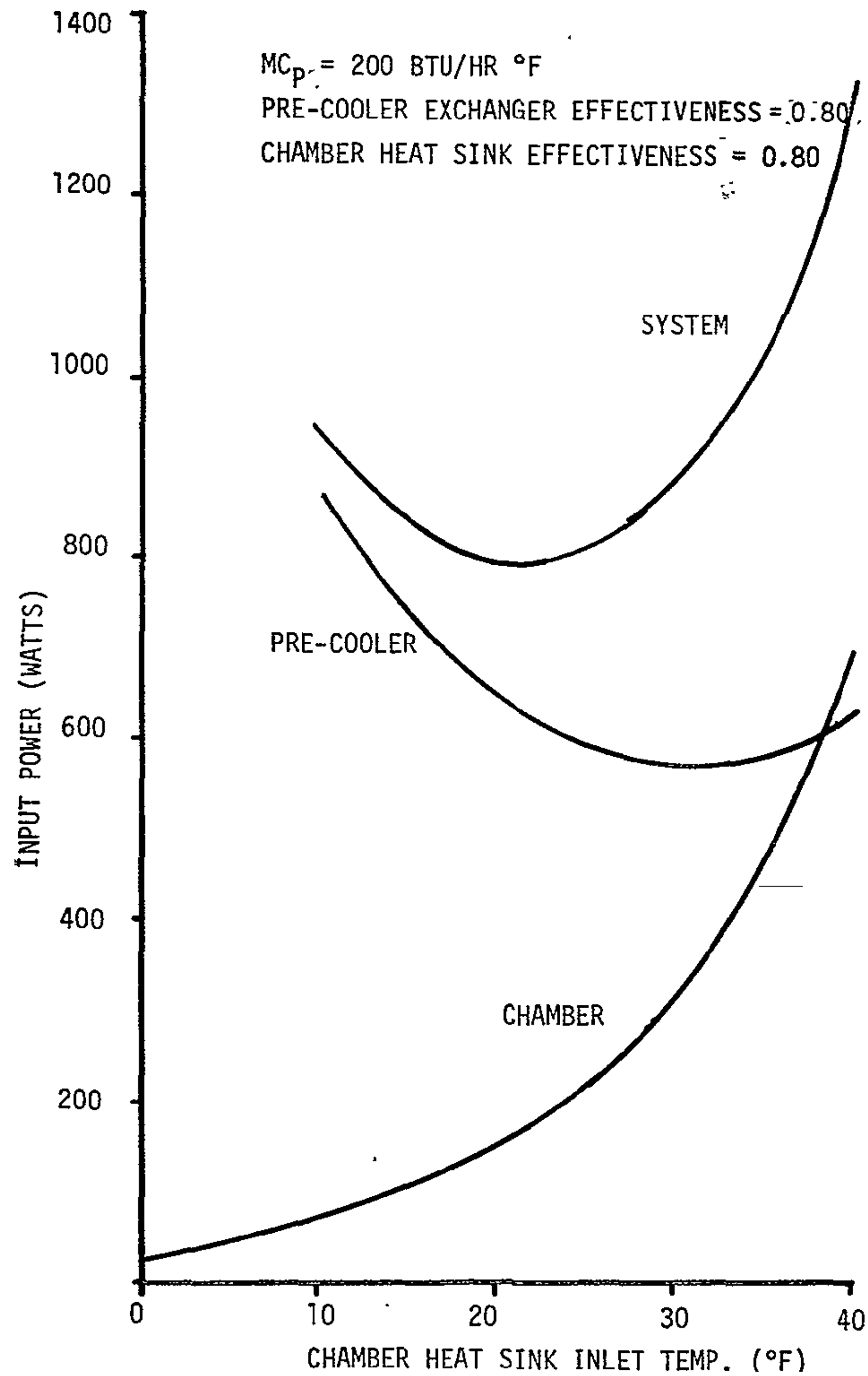


FIGURE 4.2 Effect of Chamber Inlet Temperature

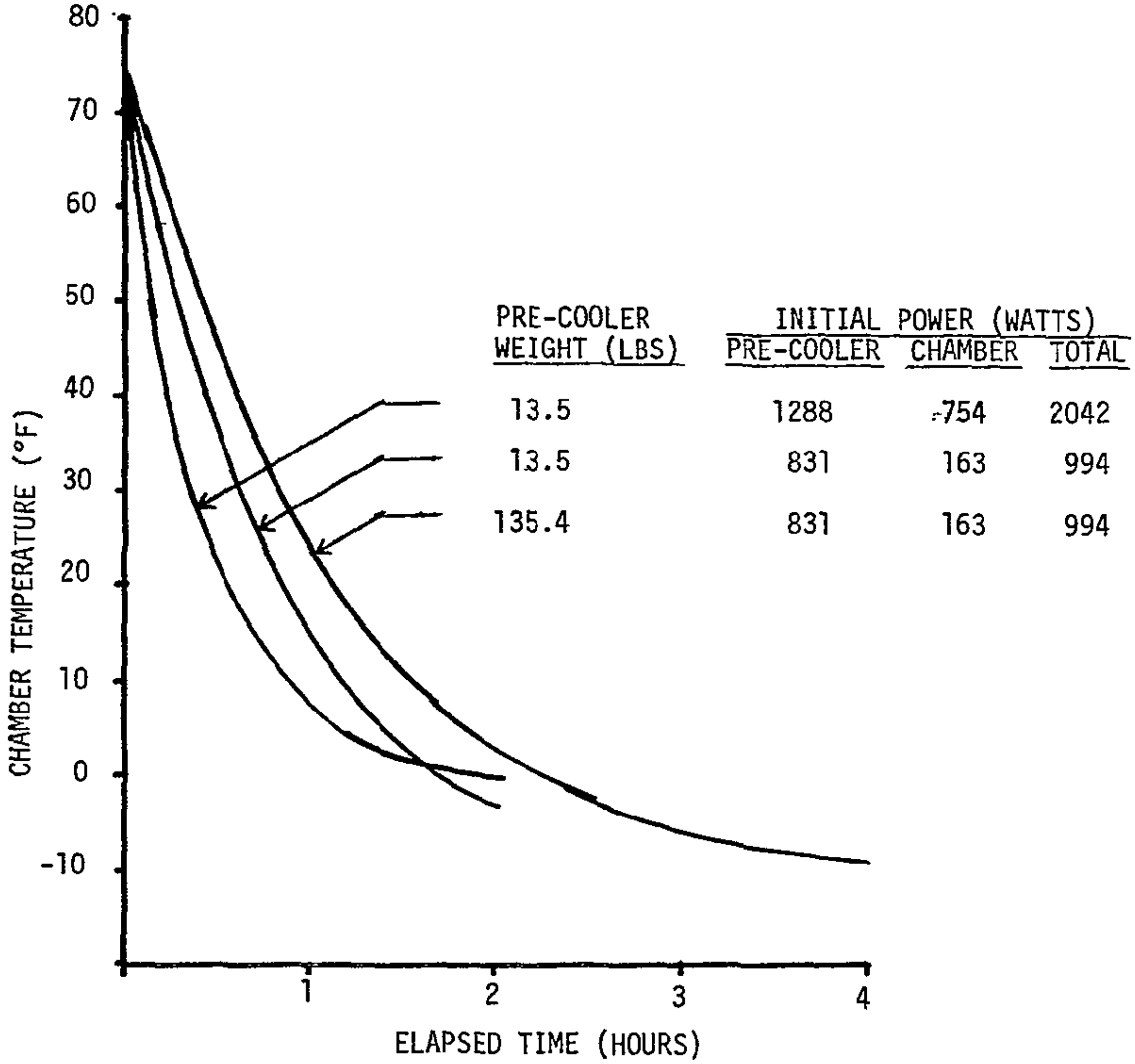


FIGURE 4.3 Pre-Cooler System Transient Performance

pre-cooler weight. Additionally, the input power to the pre-cooler as well as the chamber was increased to the largest acceptable values to yield the fastest cool down times achievable with this systems approach.

Since the cool down time was approximately 2-4 hours, an alternate design approach was considered. That is, the limiting factor in cool down time was the large thermal mass of the pre-cooler water loop. In the alternate design, the pre-cooler is completely eliminated and a staged thermoelectric cooler is used between the chamber heat sink and the chamber wall. This 3rd phase of activity is described in the next section.

5. PHASE 3 - CASCADES

5.1 Design and Performance Calculations

The configuration studied in this phase of the program was identical to that described in Phase 1 with one exception: The thermoelectric module as shown was replaced with a multi-stage thermoelectric cascade. Results of the effect of thermoelectric cascading on steady-state performance are shown in Figure 5.1.1. It is observed that the two-stage case required approximately the same input power as the optimized pre-cooler/chamber system described in Phase 2. Indeed, thermoelectrically they are nearly equivalent.

Transient cooling characteristics of an optimized 2 and 3-stage cooler are shown in Figures 5.1.2 and 5.1.3, respectively. It is observed that, in spite of the higher efficiency of the three-stage cooler, the transient performance in the region of interest is practically identical. This is due to the added mass and distributed heat pumping of the 3-stage unit versus the more compact 2-stage unit. Consequently, subsequent efforts concentrated on the two-stage design.

Further calculations showed that a slight improvement in the initial cooling transient was evidenced by increasing the thermal mass of the heat sink. Of course, a more dramatic effect could be obtained by decreasing the thermal mass of the chamber. The calculations for a chamber with 1/2 the mass of the original design (wall thickness approximately 0.31" versus 0.625") are shown in Figure 5.1.4 for a two-stage cascade. This represented the best performance that could

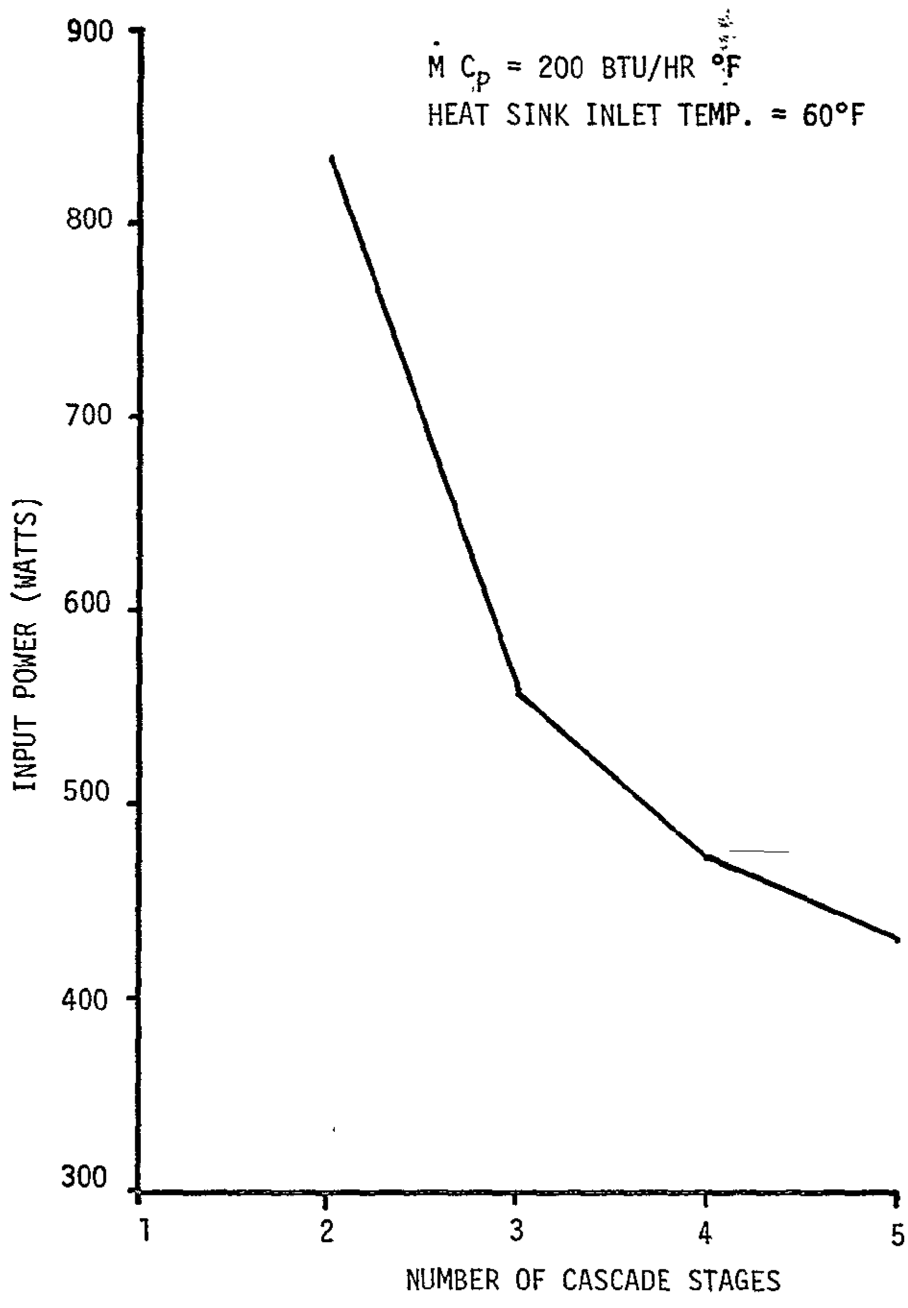


FIGURE 5.1.1 Effect of Thermoelectric Cascading (No-Pre-Cooler)

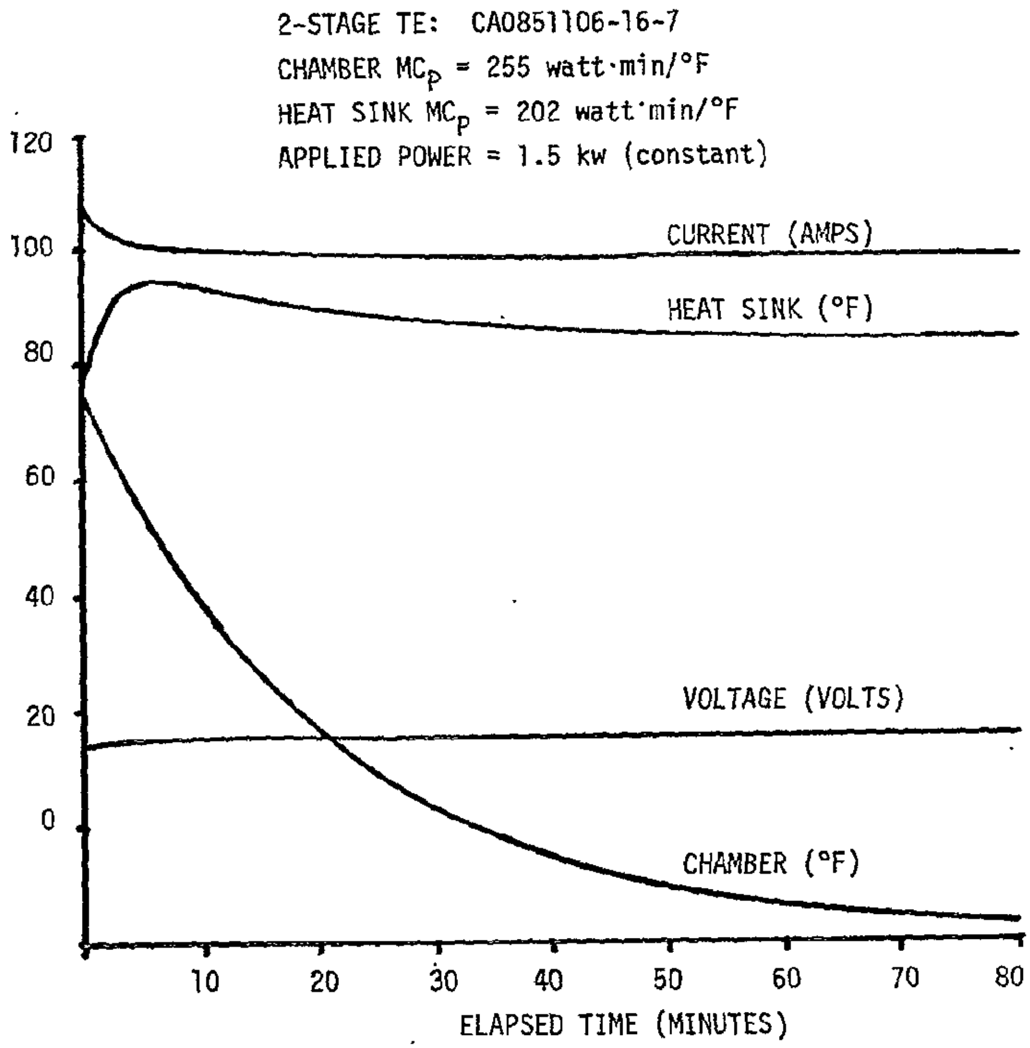


FIGURE 5.1.2 Transient Performance - Two Stage Cascade

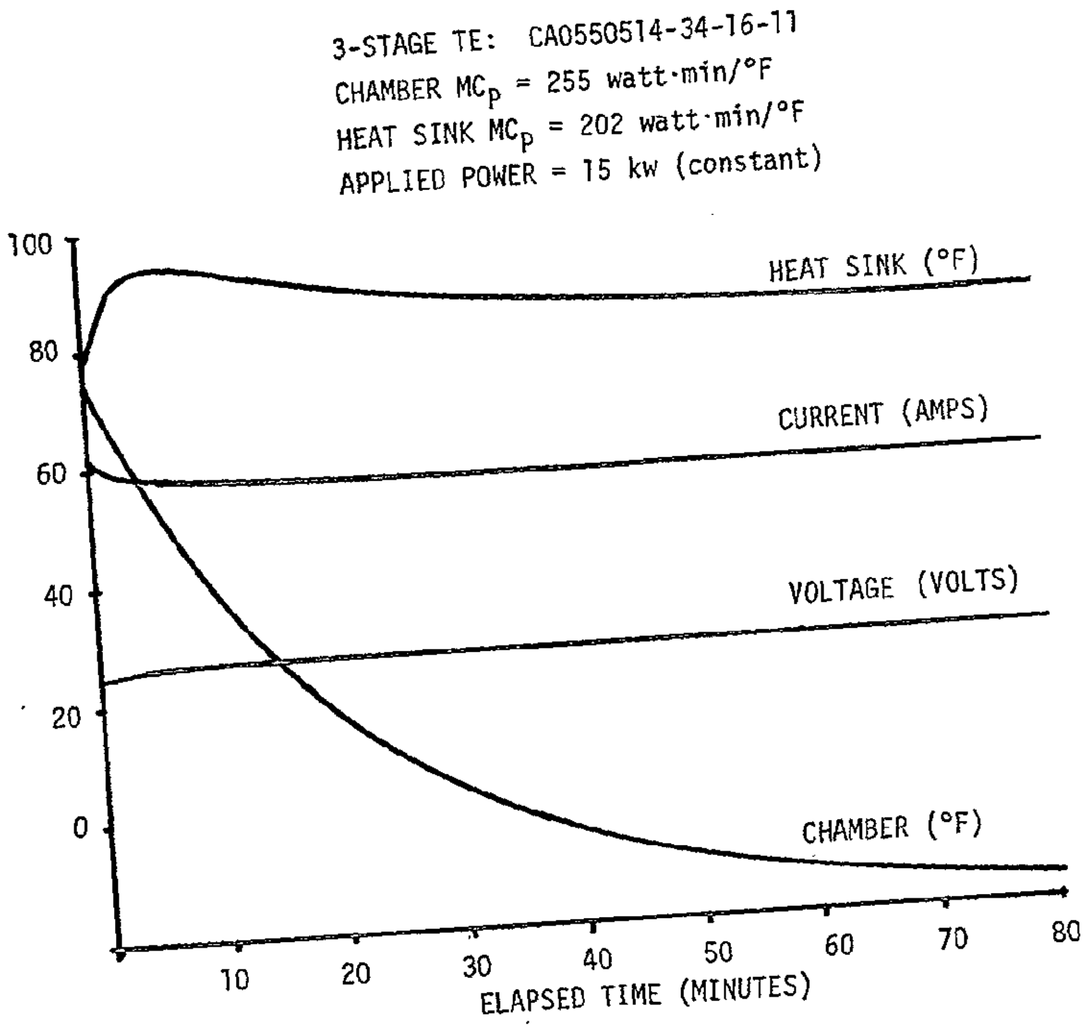


FIGURE 5.1.3 Transient Performance - Three Stage Cascade

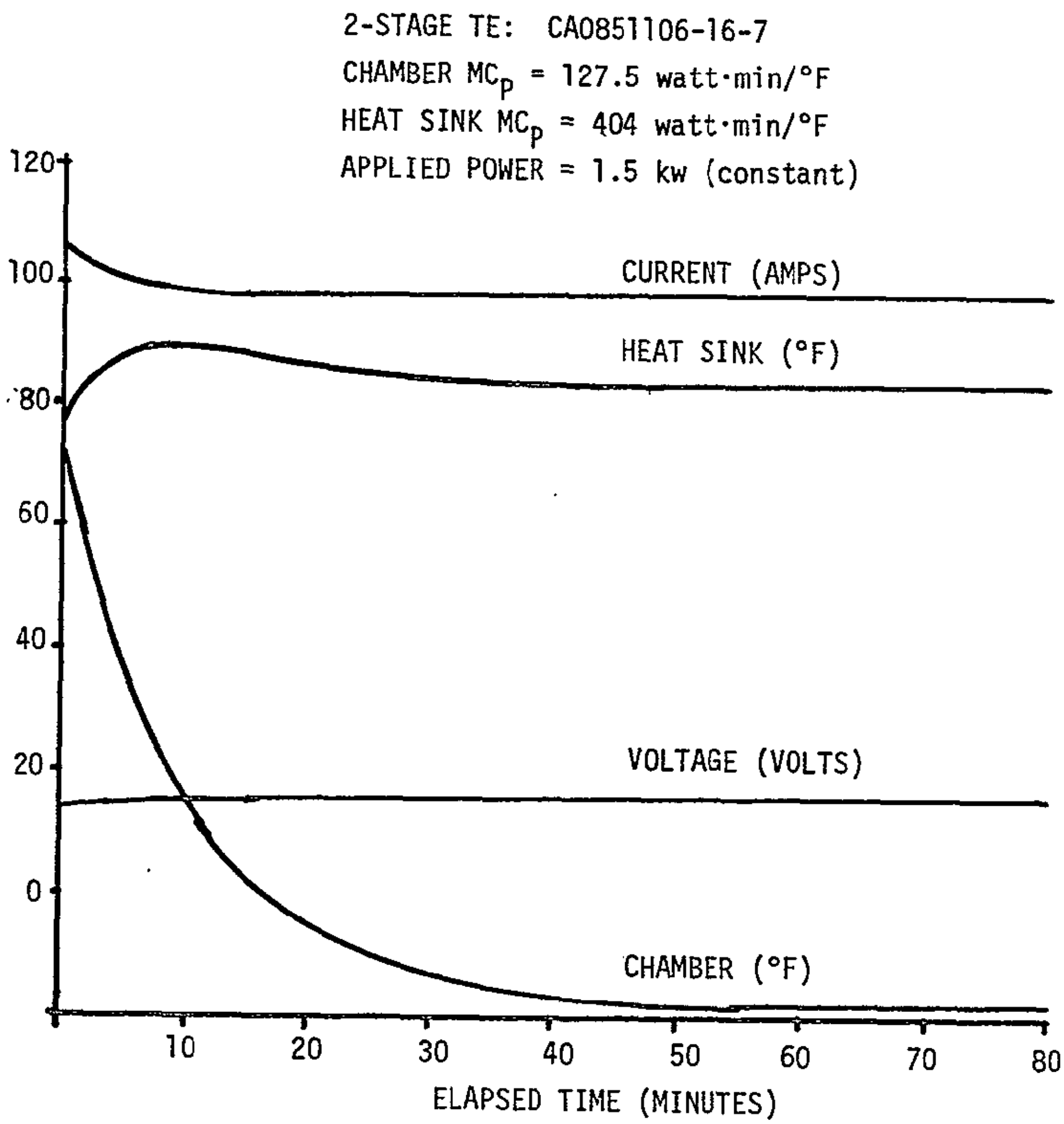


FIGURE 5.1.4 Transient Performance - Two Stage Cascade With Reduced Chamber Mass

be expected under the imposed constraints. Any further reduction in wall thickness decreases the "thermal filtering" and jeapordizes the ability to achieve desired isothermal conditions.

5.2 Hardware Delivery

In anticipation of utilizing similar coolers in the final design, MSFC placed an order for 40 two-stage cascades, Model #952-16-7, for use in a test designed by MSFC personnel. These coolers were different from those in Figures 5.1.2 and 5.1.4 in thermoelectric pellet dimensions. That is, the 952-16-7 cooler is fabricated from pellets 0.055" x 0.055" in cross-section by 0.063" high; whereas the CA0851106-16-7 cooler is fabricated from pellets 0.085" x 0.085" in cross-section by 0.1106" high.

5.3 Transient Specifications

It was at this point in the program that BWTE was first made aware of certain transient cooling specifications required for the proper execution of the cloud physics experiments. These desired cooling specifications are shown in Figure 5.3.1. This data was entered into the computer program and a simple thermostatic approach was applied. That is, the cooler power was full on if the chamber temperature was above the curve and completely off otherwise. The results of these calculations are shown in Figures 5.3.2 and 5.3.3 for the two respective cool down specifications. (The observed oscillations were arti-

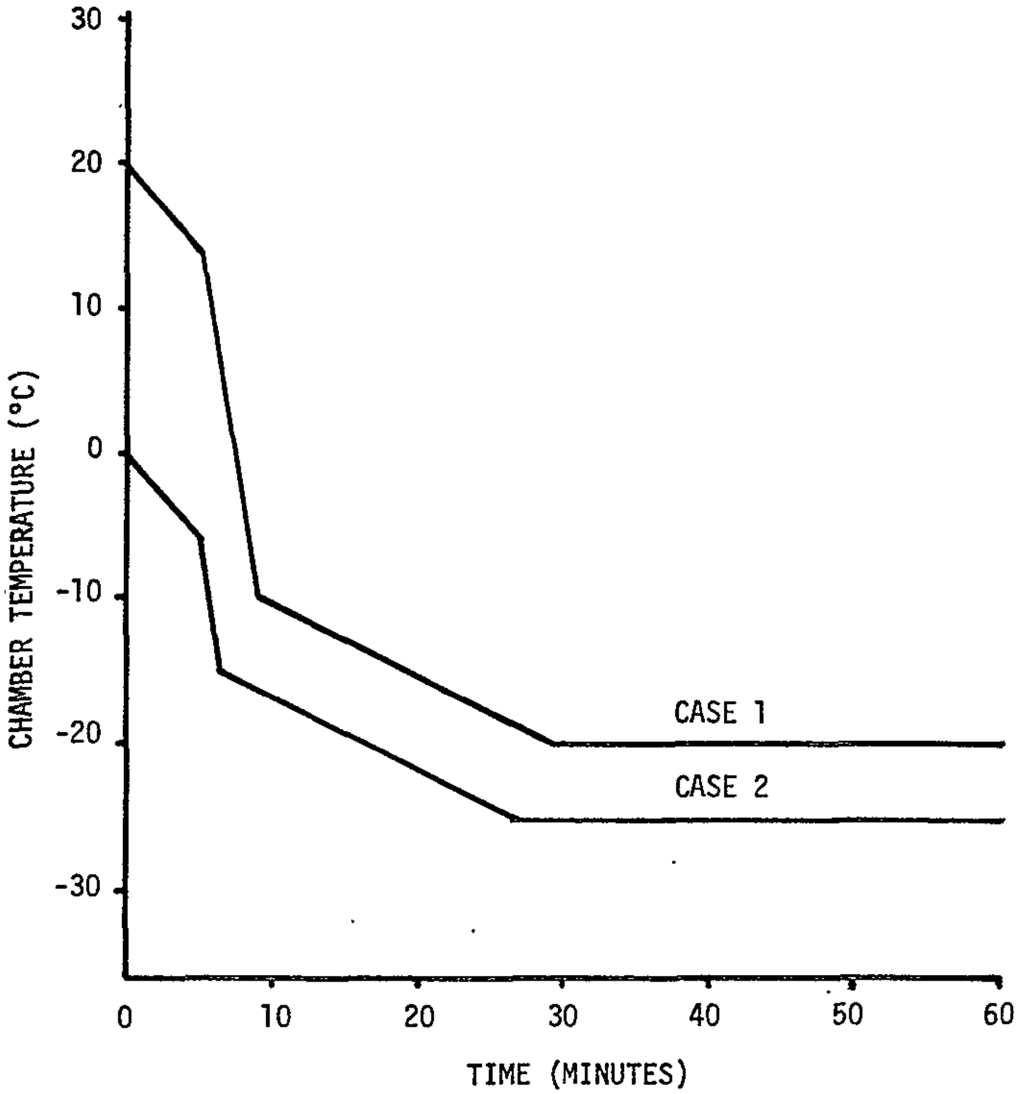


FIGURE 5.3.1 Transient Cooling Specifications

Thermostatically Applied Power = 1500 Watts
Chamber MCp = 127.5 Watt·Min/°F
Heat Sink MCp = 404.0 Watt·Min/°F
Flow Rate MCp = 300 BTU/HR °F at 60°F

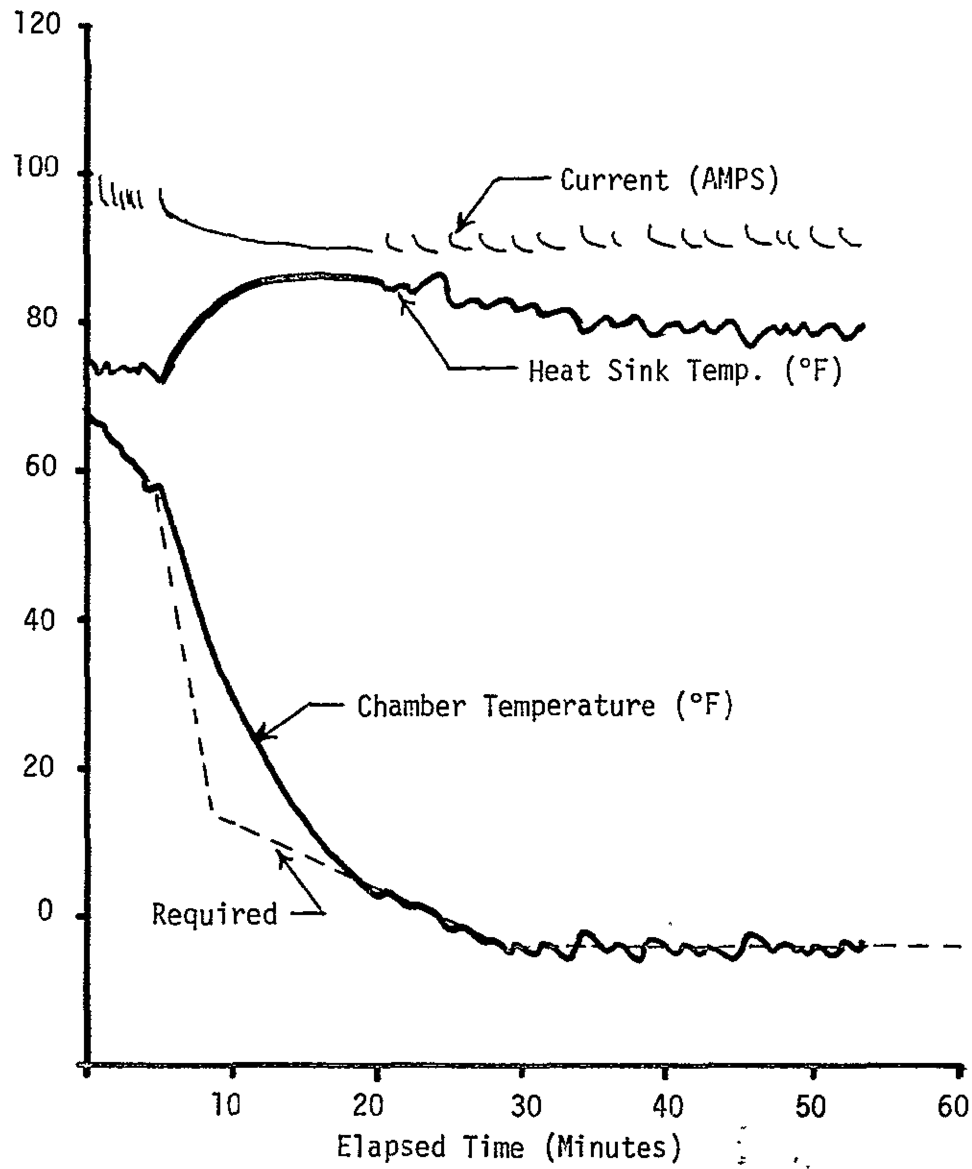


FIGURE 5.3.2 Transient Performance of Thermoelectric Cloud Chamber, Case I

Thermostatically Applied Power = 1500 Watts
Chamber MCp = 127.5 Watt·Min/°F
Heat Sink MCp = 404.0 Watt·Min/°F
Flow Rate MCp = 300 BTU/HR °F at 60°F

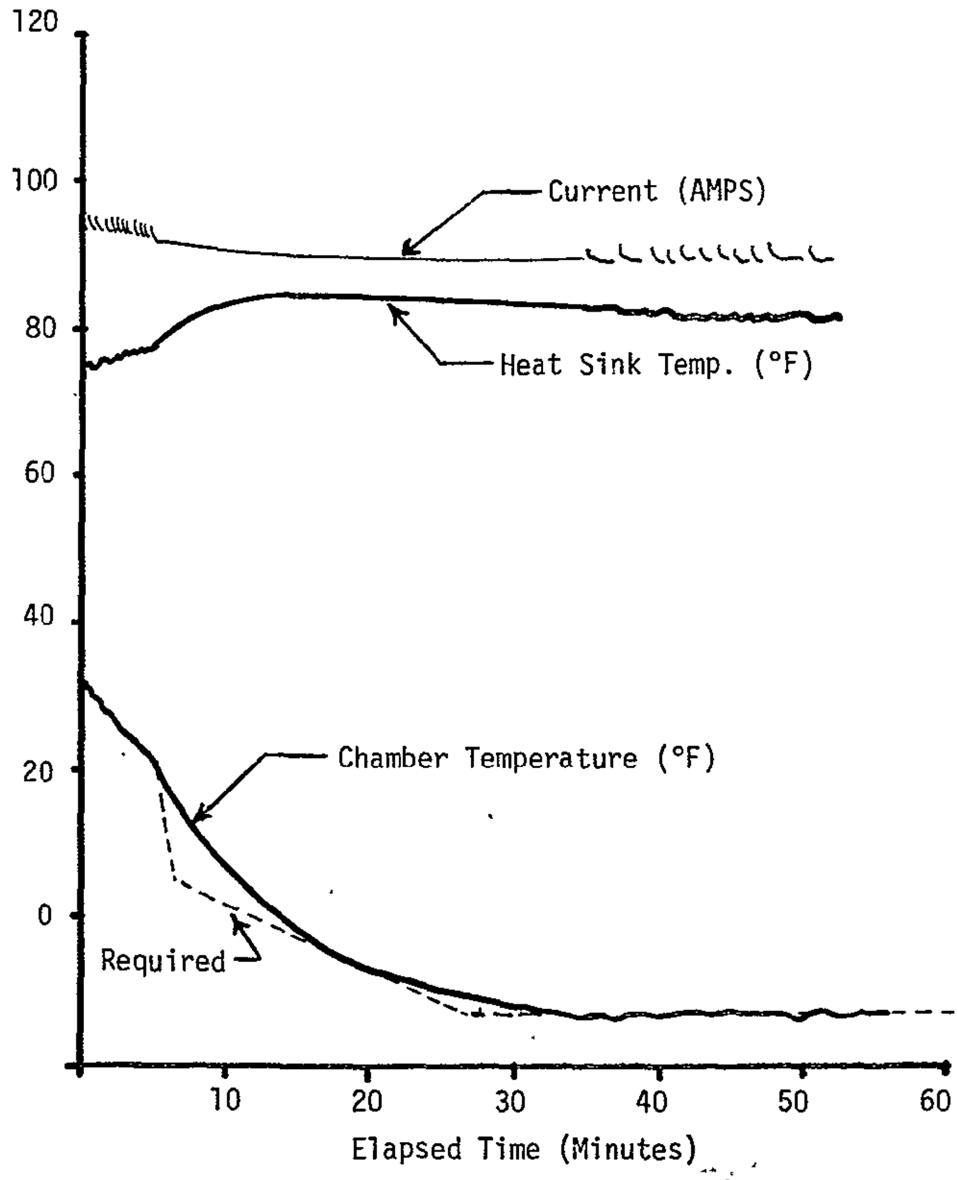


FIGURE 5.3.3 Transient Performance of Thermoelectric Cloud Chamber, Case 2

facts of the program due to arbitrary time interval selections.)

Every attempt was made to maximize performance: The full power budget of 1.5 kw, the maximum heat sink flow rate of 300 BTU/hr°F, the minimum heat sink flow temperature of 60°F, a "double-sized" heat sink mass, and a "minimum" chamber wall thickness of 0.31 inches. Nevertheless, the steeper portions of the spec. curves could not be met in either transient case.

Furthermore, fundamental calculations based solely on the required cool down rate and the chamber mass revealed that 2960 watts of heat pumping was required down to 14°F chamber temperature. Consequently, the required Coefficient of Performance COP = heat pumped input power, was approximately 2.0. This value was totally unattainable by any thermoelectric device operating over the required 66°F temperature differential.

It was concluded from the above calculations that thermoelectrics could not provide the degree of cooling on a real time basis to meet the desired transient condition given in Figure 5.3.1. Although this transient was not a contractual requirement on the part of BWTE, MSFC decided to seek yet another approach. This involved a totally different method of cooling the chamber and a redefinition of the scope of effort required by BWTE. This fourth and final phase of this contract is discussed in the following section.

6. PHASE 4 - RESERVOIR CHILLER

This final phase of the contract required a contract modification to formally redefine the scope of effort. In general, the revised statement of work was concerned with the thermoelectric cooling of a liquid reservoir which was to be used, in turn, to cool the chamber. The cool down of the chamber itself was no longer the responsibility of BWTE.

6.1 Design

The conceptual schematic of the expansion chamber thermal control system is shown in Figure 6.1.1. The thermoelectric chiller on which BWTE was to concentrate its activities is shown in more detail in Figure 6.1.2. Due to the constraints of funding and delivery schedule, it was mutually decided that BWTE utilize approximately 1100 watts input power and simply design the chiller to extract the maximum heat with the cold side at -30°C and the hot side at +30°C.

6.1.1 Thermoelectric - A two-stage design was chosen for this application. The optimum couple ratio from the bottom stage to the top stage was 2 to 3 depending on the final operating temperatures of the respective sinks. The best mechanical versus thermal trade-off in design was to use a standard 12 x 12 T.E. pellet array as the bottom and a standard 8 x 8 T.E. pellet arrray as the top stage. These stages had different heights but identical width envelope

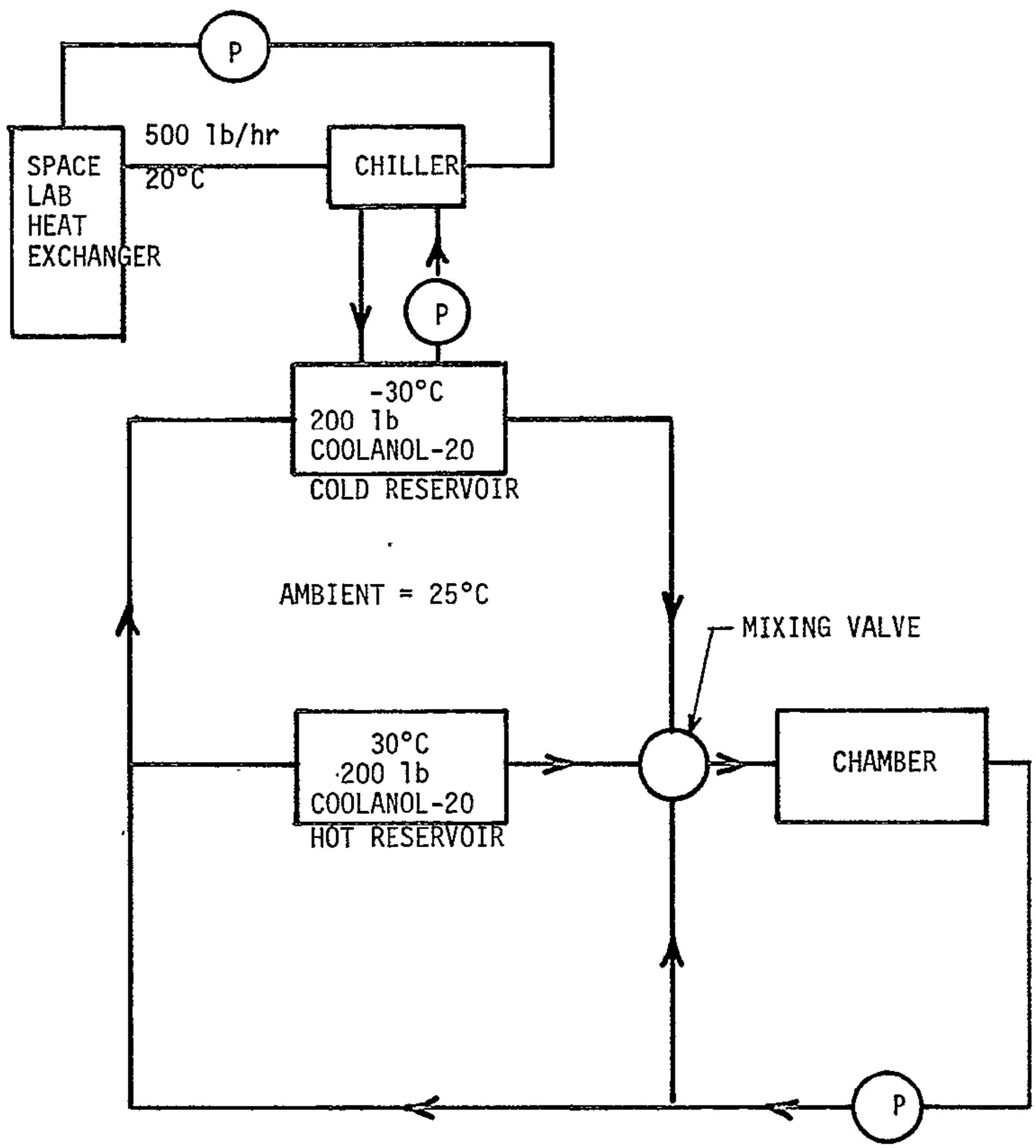


FIGURE 6.1.1 Conceptual Schematic of Chamber Thermal Control System

dimensions so that the assembled cascade had the overall appearance of a single parallelpiped module as opposed to the normal pyramid structure. The resulting couple ratio was 70/31 or 2.26 in good agreement with optimization requirements.

The resulting optimum input power for each thermoelectric cascade was 5.75 volts at 3.0 amps. Since the maximum allowed system voltage was 22 volts, three cascades in series were selected yielding a system voltage of 17.3 volts. An even number of these 3 cascade sets was required due to the symmetry of the design (Figure 6.1.1.1). Consequently, 18 sets were chosen yielding an input power requirement of 17.3 volts at 54.0 amps. The calculated heat pumping at the design point was 2.5 watts per cascade or 135 watts for the system. In the turn-on condition when the entire system was at ambient, the heat extraction rate was about 500 watts. The net heat extracted from the fluid, of course, was slightly lower than these values due to thermal losses.

The electrical resistance was measured on each cascade manufactured. The observed range was 1.58 to 1.70 ohms. The two resistance extremes were chosen, in addition to two other cascades selected at random, for zero load ΔT measurements. The results are given in Table 6.1.1.1:

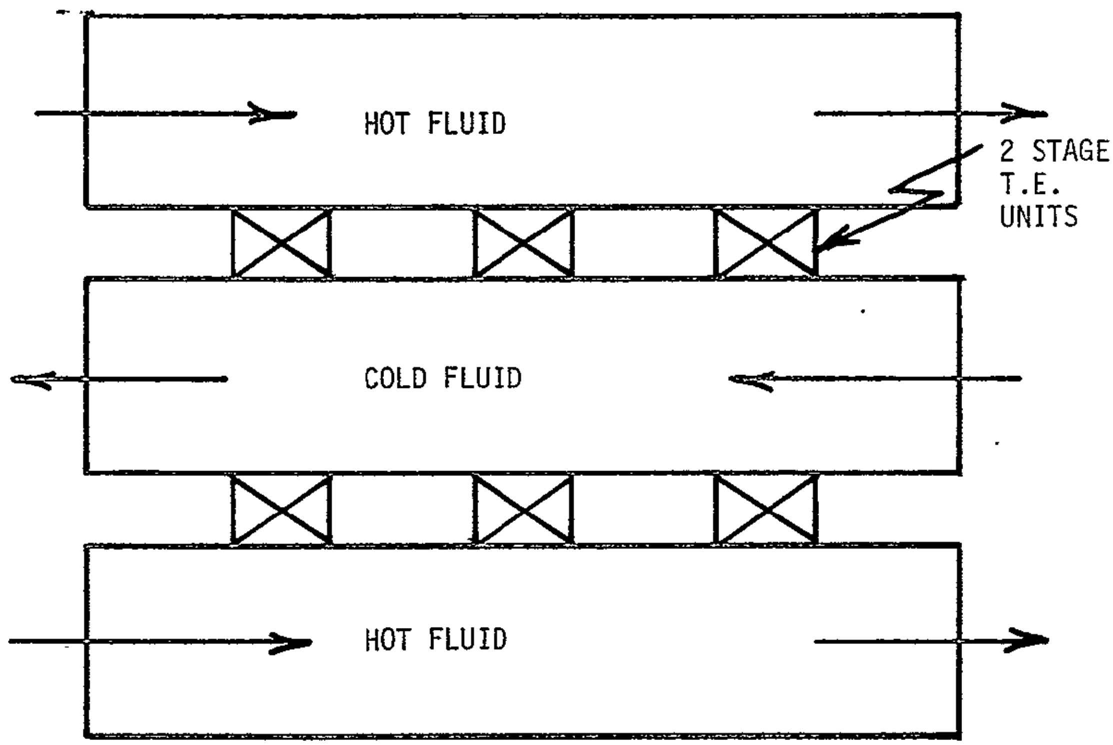


FIGURE 6.1.1.1 Concept of Fluid Chilling Device

Table 6.1.1.1
CASCADE TEST RESULTS, HEAT SINK = 35°C

Serial No.	I(amps)	V(volts)	ΔT(°C)	Q(watts)	Res.(Ω)
8	4.08	8.37	90.5	0.0	1.70
17	4.10	7.60	87.0	0.0	1.58
25	4.02	7.95	90.5	0.0	1.65
39	4.07	7.90	91.7	0.0	1.62
Predicted	4.05	7.50	89.0	0.0	1.58
Predicted Opt.	3.03	5.75	65.0	2.5	1.58

The observed performance variance within this set of cascades was due most likely to thermoelectric material parameter variance. However, none were rejected since the average of the coolers tested exceeded the expected cooling performance.

6.1.2 Heat Sinks - The envelope dimensions of the heat sinks were designed to be consistent with the layouts of the thermoelectric designs. Finned passages were used such that the maximum expected ΔT between the sinks and the outlet fluid was 5.8°C and 1.2°C for the hot and cold sinks, respectively.

6.2 Assembly

A complete set of drawings was generated governing the fabrication of the thermoelectric chiller. The main assembly drawing was given

the BWTE number: 2600-0018, dated 7/2/76. The various stages of assembly are depicted in Figures 6.2.1 through 6.2.4.

6.3 Acceptance Test

An acceptance test was designed as shown schematically in Figure 6.3.1. The 12" x 18" x 18" reservoir was insulated with 4" of polyurethane. The cold fluid piping was insulated with 2" (on radius) of Armstrong insulation with K = 0.0208 BTU/hr ft °F. The total length of the piping was 5.2 ft. Figures 6.3.2 and 6.3.3 are photographs of the system assembled as ready for test.

A zero load ΔT test was made prior to the system simulation test. This test differed from the system test in that no cold fluid was allowed into the chiller. This test, of course, had a much faster transient and allowed a determination of the quality of the thermoelectric chiller apart from the system parameters. Detailed test measurement data sheets from both tests are given in Tables 6.3.1 and 6.3.2.

6.4 Analysis - The calculated heat loss conductance of the cold system was 0.4859 watts/°C with 0.2536 watts/°C due to the reservoir and 0.2323 watts/°C due to the piping. The thermal capacitance of the cold system minus the chiller was 2560 watt min/°C. The heat sinks plus the water contained in them was 242.7 watt min/°C. The cold sink alone (zero load test) was 33.8 watt min/°C and filled with the ethylene glycol-water mixture was 49.9 watt min/°C.

FIGURE 6.2.1

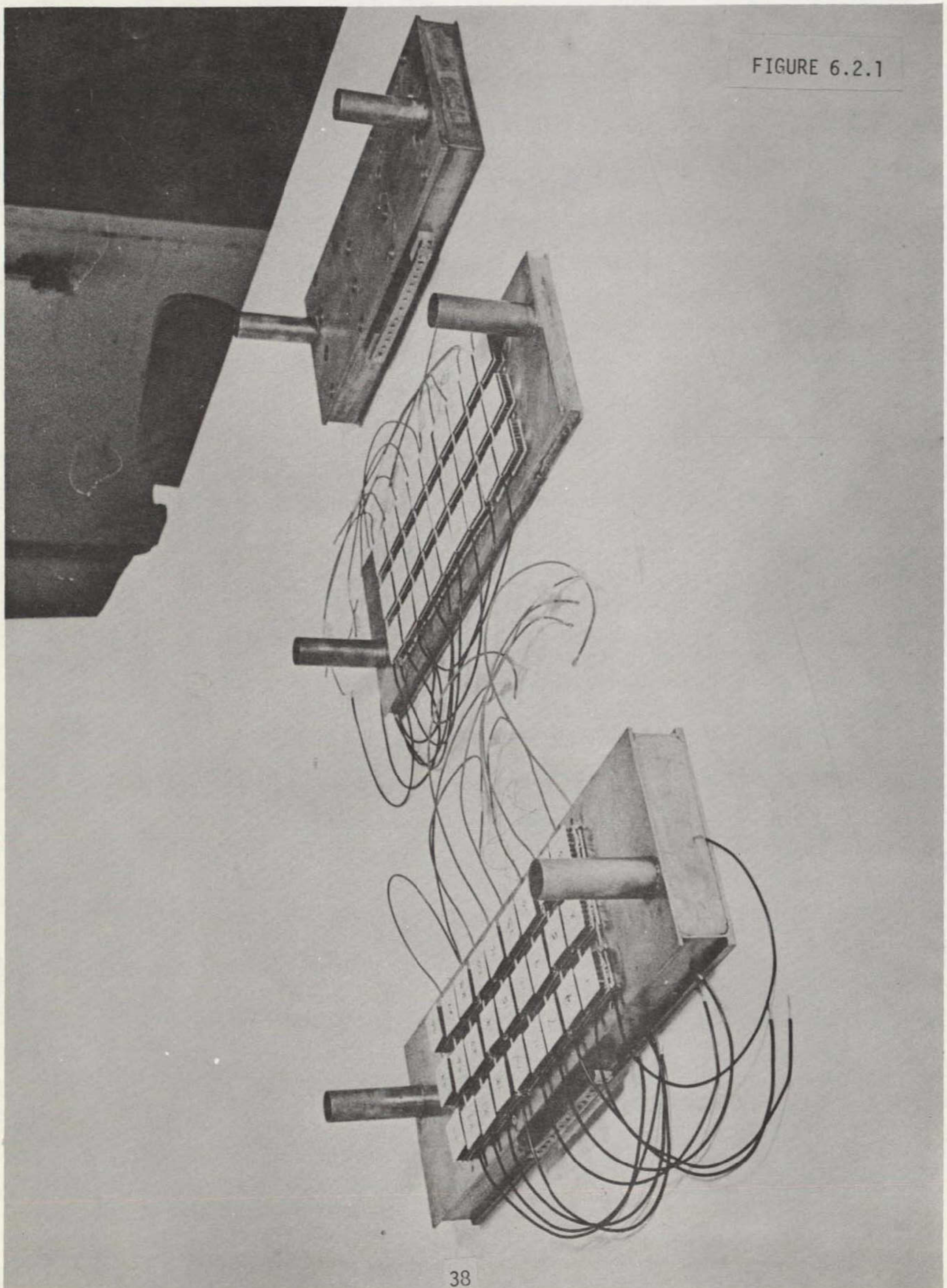
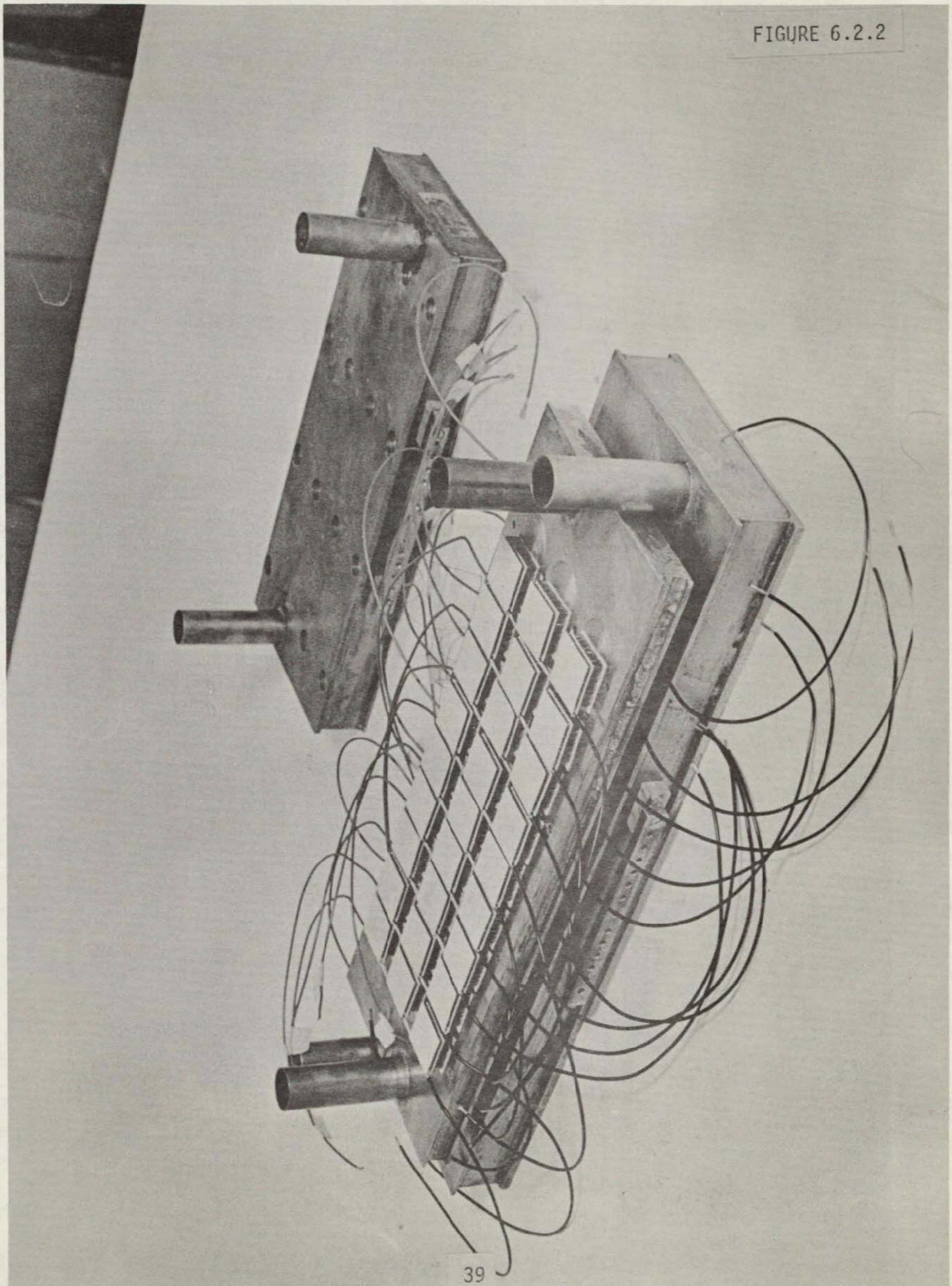


FIGURE 6.2.2



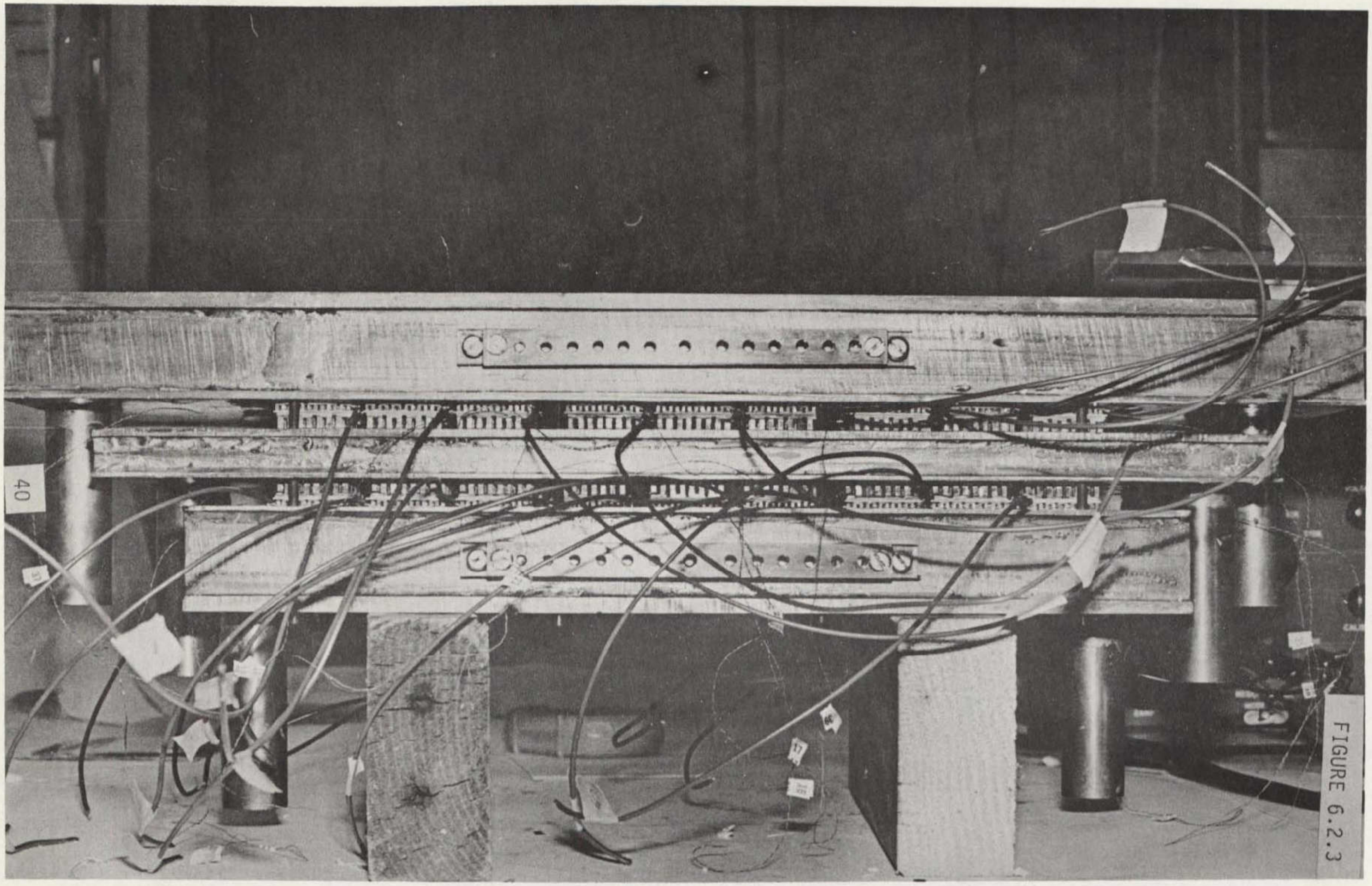
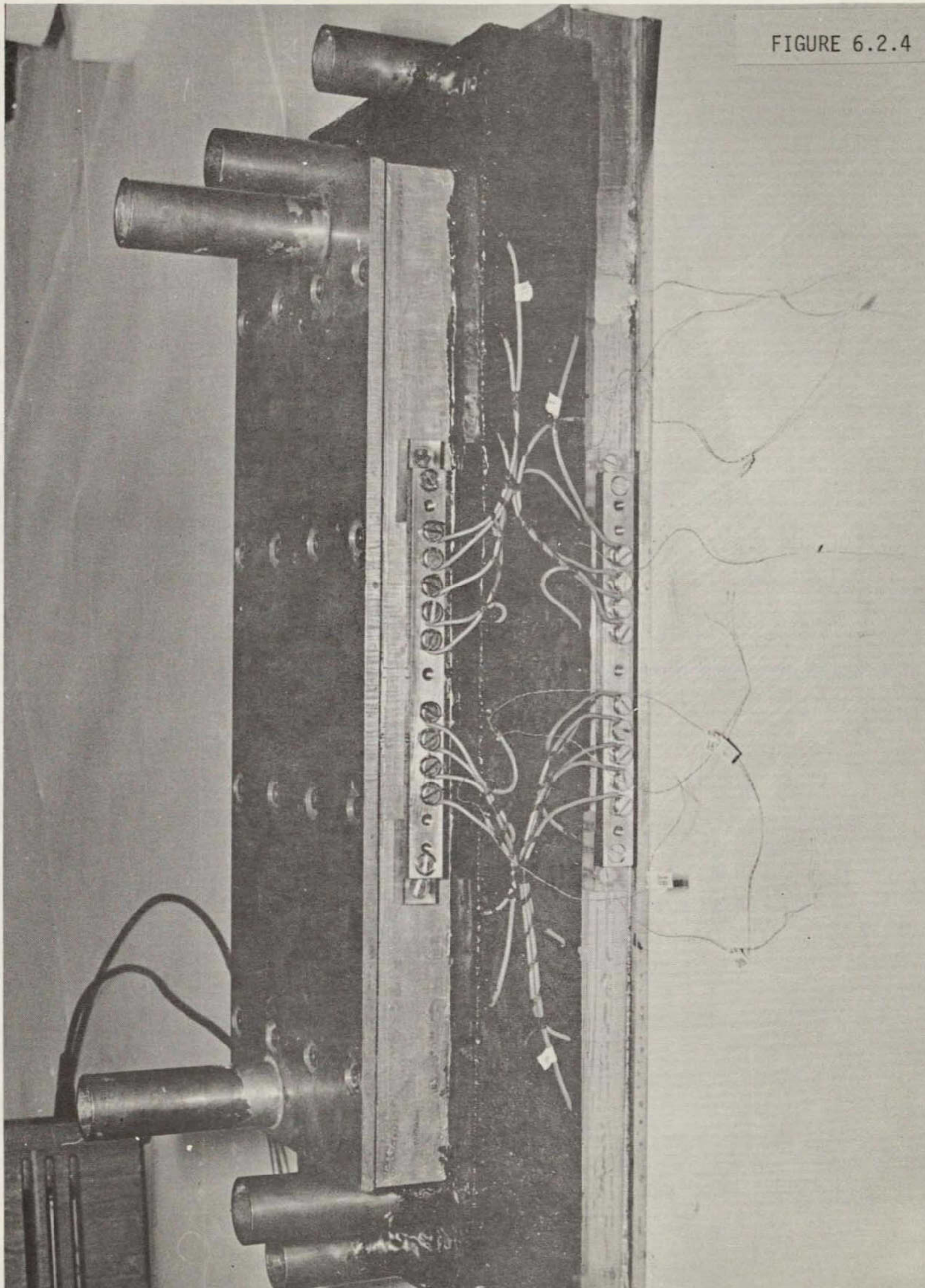


FIGURE 6.2.3

FIGURE 6.2.4



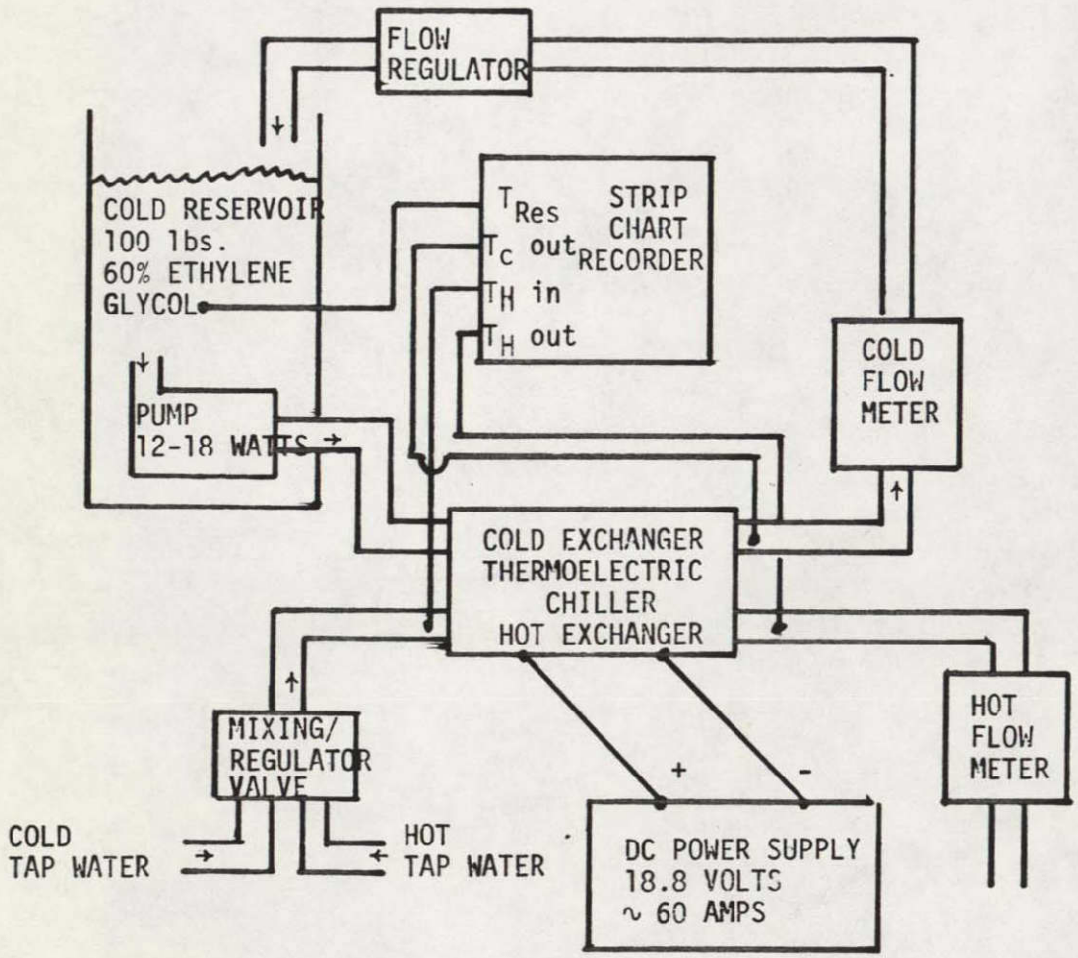
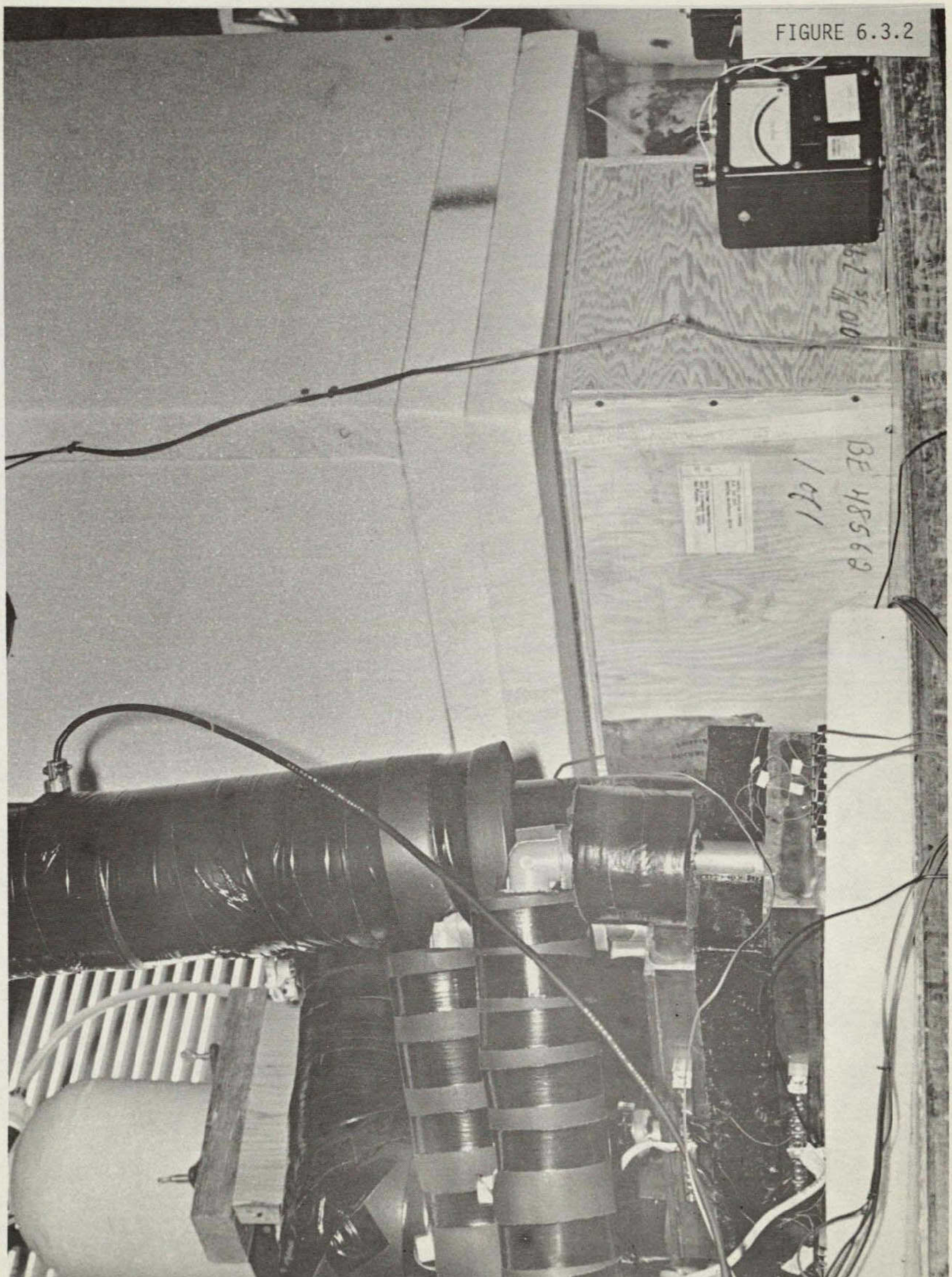


FIGURE 6.3 SCHEMATIC OF APPARATUS FOR ACCEPTANCE TEST

FIGURE 6.3.2



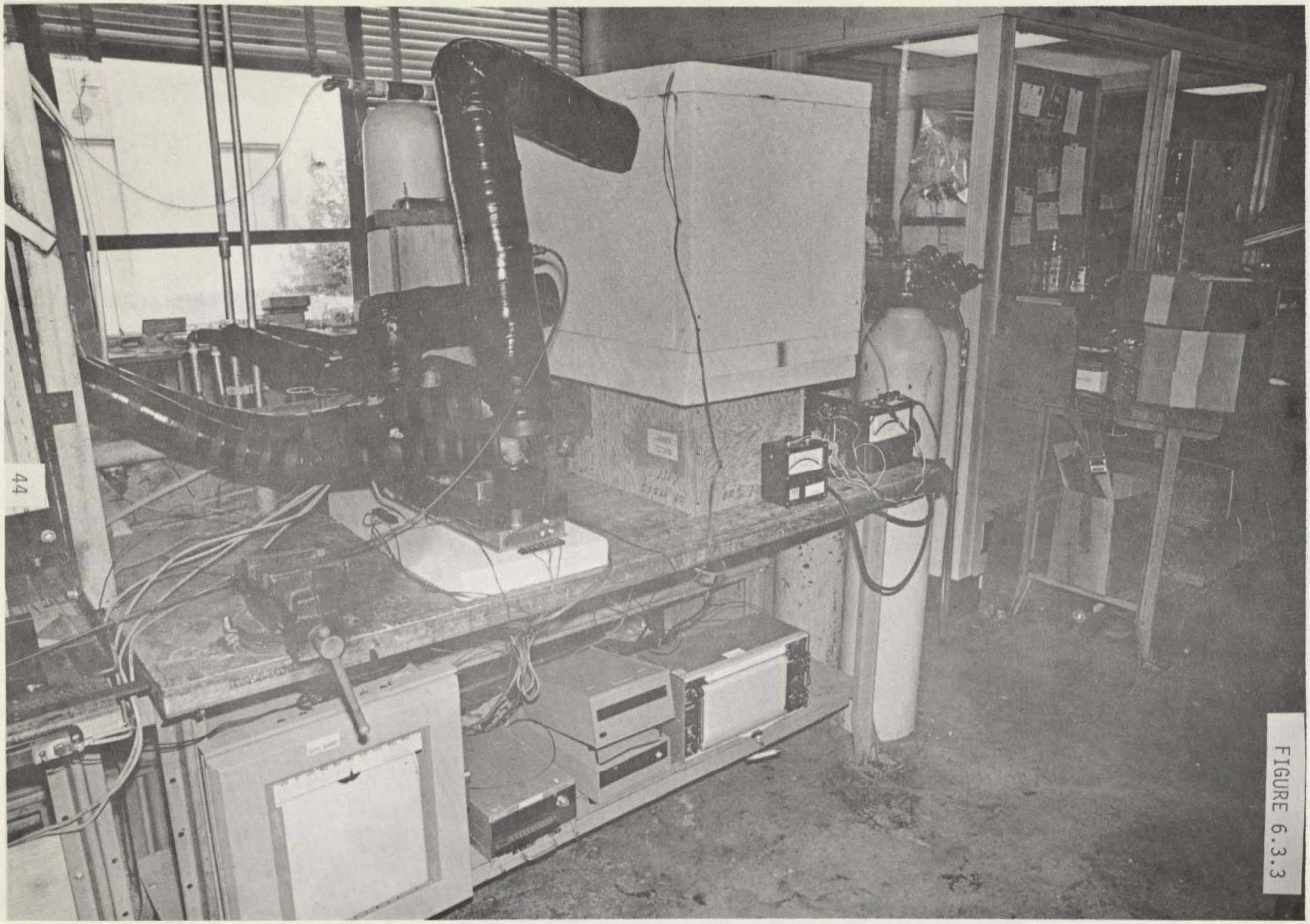


FIGURE 6.3.3

TABLE 6.3.1

NO LOAD ΔT MEASUREMENT: MARSHALL CHILLER   Date 9/5/76
(1Min/Set of Readings)

Reading	Units / Meter Position	t=0	t=5 min	t=10 min	t=15 min	t=20 min	t=25 min	t=30 min
Water Flow Upper Sink	ml/min	1890	1890	1890	1890	1890	1890	1890
Water Flow Lower Sink	ml/min	1890	1890	1890	1890	1890	1890	1890
Applied Voltage	VDC	0	19.2	19.2	19.0	19.0	19.0	19.0
Applied Current	AMP	0	62	61	61	60.8	60.8	60.8
T_H Cascade #42	°C / A1	18.8	26.3	25.3	24.8	24.6	24.5	24.5
T_H Stage #1 Cascade #42	°C / A2	20.9	25.1	26.2	26.6	26.7	26.7	26.7
T_C Cascade #42	°C / A3	19.3	-27.5	-42.7	-47.4	-49.3	-50.0	-50.2
T-Upper Sink Inlet End	°C / A4	18.9	19.4	19.0	+19.0	19.0	18.8	19.1
T-Upper Sink Middle	°C / A5	18.8	23.9	22.9	22.0	21.8	22.5	21.6
T-Cold Exch. Upper Plate Inlet End	°C / A6	19.2	-22.6	-38.7	-44.7	-46.9	-47.7	-48.0
T-Cold Exch. Upper Plate Middle	°C / A7	19.2	-28.8	-43.2	-48.4	-50.3	-51.0	-51.2
T-Cold Exch. Upper Plate Outlet End	°C / A8	19.3	-25.3	-40.9	-46.4	-48.5	-49.3	-49.5

Table 6.3.1 (Con't)
NO LOAD ΔT MEASUREMENT: MARSHALL CHILLER
(1 Min/Set of Readings)

Reading	Units / Meter Position	t=0	t=5 min	t=10 min	t=15 min	t=20 min	t=25 min	t=30 min
T-Cold Exch. Lower Plate Inlet End	°C / A9	19.3	-25.0	-40.1	-46.1	-48.3	-49.2	-49.2
T-Lower Sink Inlet End	°C / A10	18.9	21.4	20.3	20.4	20.3	20.3	20.1
T-Stage Cascade #9	°C / A11	18.9	27.8	26.6	26.2	26.1	26.0	25.9
T-Ethylene Glycol Outlet	°C / A12							
T-Inlet H_2O Upper Sink	°F / B1	64.5	64.1	64.1	63.9	63.8	63.7	63.6
T-Outlet H_2O Upper Sink	°F / B2	64.5	73.1	72.9	71.6	71.3	71.1	71.1
T-Inlet H_2O Lower Sink	°F / B3	64.6	64.3	64.3	64.1	64.0	64.0	63.8
T-Outlet H_2O Lower Sink	°F / B4	64.8	73.2	72.4	71.9	71.6	71.6	71.5

TABLE 6.3.2 Date 9/7/76

MARSHALL CHILLER PERFORMANCE TEST

Reading	Units / Meter Position	t=0	t=15 min	t=30 min	t= 1 hr.	t= 2 hrs.	t=3 hrs.
Water Flow Upper Sink	ml/min	1890	1890	1890	1890	1890	1890
Water Flow Lower Sink	ml/min	1890	1890	1890	1890	1890	1890
Applied Voltage	VDC	0	18.5	18.4	18.5	18.3	18.5
Applied Current	AMPS	0	61.6	61.5	62.0	61.0	60.8
T_H Cascade #42	°C / A1	18.3	27.2	27.2	26.8	26.1	26.0
T_H-Stage #1 Cascade #42	°C / A2	19.6	25.7	26.6	27.0	26.3	26.0
T_C Cascade #42	°C / A3	24.3	15.3	12.8	8.0	-0.2	-6.4
T-Upper Sink Inlet End	°C / A4	18.2	19.5	19.6	19.6	19.0	19.1
T-Upper Sink Middle	°C / A5	18.4	25.7	25.1	25.5	24.9	25.7
T-Cold Exch. Upper Plate Inlet End	°C / A6	24.4	19.5	16.7	11.7	3.3	-3.3
T-Cold Exch. Upper Plate Middle	°C / A7	24.3	14.7	12.2	7.4	-0.7	-6.9
T-Cold Exch. Upper Plate Outlet End	°C / A8	24.3	13.8	11.5	6.7	-1.3	-7.4

Table 6.3.2 (Con't)
MARSHALL CHILLER PERFORMANCE TEST

Reading	Units / Meter Position	t=0	t=15 min	t=30 min	t=1 hr.	t=2 hrs.	t=3 hrs.
T-Cold Exch. Lower Plate Inlet End	°C / A9	24.8	20.0	17.2	12.0	3.4	-3.5
T-Lower Sink Inlet End	°C / A10	18.4	23.5	23.6	23.5	22.6	22.2
T-Ethylene Glycol Inlet	°C / A11	25.0	22.4	19.4	14.0	4.9	-2.3
T-Ethylene Glycol Outlet	°C / A12	24.6	17.0	14.8	10.0	1.4	-5.6
T-Inlet H_2O Upper Sink	°F / B1	63.0	62.4	62.2	62.3	61.3	62.2
T-Outlet H_2O Upper Sink	°F / B2	63.1	73.0	72.7	72.1	71.4	71.8
T-Inlet H_2O Lower Sink	°F / B3	63.5	63.3	63.1	62.8	62.5	62.8
T-Outlet H_2O Lower Sink	°F / B4	64.0	74.0	73.7	73.0	72.4	72.5
Pump I/V	AMP/VOLT	1.27/12.0	1.26/11.9	1.26/11.9	1.30/12.0	1.35/12.0	1.36/1.20
f (Flow Meter)			250	262	258	250	248

Table 6.3.2 (Con't)
MARSHALL CHILLER PERFORMANCE TEST

Reading	Units / Meter Position	t=4 hrs.	t=5.2 hrs.	t=6 hrs.	t=7 hrs.	t=7 hrs. 53 min.	
Water Flow Upper Sink	ml/min	1890	1890	1890	1890		
Water Flow Lower Sink	ml/min	1890	1890	1890	1890		
Applied Voltage	VDC	18.3	18.3	18.6	18.6		
Applied Current	AMPS	59.6	60	60.0	60		
T_H Cascade #42	°C / A1	25.8	24.9	25.2	24.8		
T_H-Stage #1 Cascade #42	°C / A2	25.6	25.3	25.3	24.9		
T_C Cascade #42	°C / A3	-12.9	-18.7	-22.0	-25.3		
T-Upper Sink Inlet End	°C / A4	19.0	18.8	18.9	18.5		
T-Upper Sink Middle	°C / A5	25.1	23.9	24.2	23.2		
T-Cold Exch. Upper Plate Inlet End	°C / A6	-10.1	-16.1	-19.5	-22.9		
T-Cold Exch. Upper Plate Middle	°C / A7	-13.4	-19.2	-22.4	-25.7		
T-Cold Exch. Upper Plate Outlet End	°C / A8	-13.7	-19.4	-22.5	-25.6		

Table 6.3.2 (Con't)
MARSHALL CHILLER PERFORMANCE TEST

Reading	Units / Meter Position	t=4 hrs.	t=5.2 hrs.	t=6 hrs.	t=7 hrs.	t=7 hrs. 53 min.	
T-Cold Exch. Lower Plate Inlet End	°C / A9	-10.4	-16.3	-19.9	-23.5		
T-Lower Sink Inlet End	°C / A10	21.5	21.3	21.2	20.4		
T-Ethylene Glycol Inlet	°C / A11	-9.7	-16.0	-20.0	-23.6	-26.3	
T-Ethylene Glycol Outlet	°C / A12	-12.5	-18.2	-21.8	-25.1	-28.6	
T-Inlet H 0 Upper Sink	°F / B1	62.3	61.6	62.1	62.0		
T-Outlet H 0 Upper Sink	°F / B2	71.4	70.2	71.0	69.9	loss flow in pump	
T-Inlet H 0 Lower Sink	°F / B3	63.2	62.7	63.2	62.7		
T-Outlet H 0 Lower Sink	°F / B4	72.2	71.3	71.7	70.5		
Pump I/V	AMP/VOLT	1.35/11.8	1.58/13.1	2.0/15.0	2.55/17.6		
f (Flow Meter)		240	220	230	215	170	

A summary of the calculated parameters at the transient condition where calculations were arbitrarily terminated is given in Tables 6.4.1 and 6.4.2 for both test simulations. The calculated results of the most important system parameters throughout the entire cool down period are shown as the solid curves in Figures 6.4.1 and 6.4.2. The actual test data are plotted onto these calculations for comparison.

It is observed that the actual current is below the predicted values. This is due to the lower calculated versus measured cascade resistance as shown in Table 6.1.1.1. However, the cool down characteristics illustrated in Figures 6.4.1 and 6.4.2 were in excellent agreement with predictions. The fact that the heat sink ran at lower than predicted temperatures was consistent with lower than calculated power consumed and exhausted into the heat sinks.

Improvements could be made in the thermal model by determining the parameters of the actual thermoelectric material composing the cascades and exchanging the resulting formulae with the "standard" formulae utilized in the model. Nevertheless, the basic thermal model is sufficiently accurate for use as a tool to study various parametizations of the system.

6.5 Performance Predictions

Performance prediction calculations were made using the computer model verified by the acceptance tests. No attempt was made to improve or otherwise change the mathematical model, thus, the same slight discrepancy in electrical current and corresponding heat sink temperature

TABLE 6.4.1 Date 11/11/76

ZERO LOAD ΔT PERFORMANCE DESCRIPTION
54 TE UNITS, MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

Thermoelectric Device Physical Description

Height (inch) = 0.4300 Weight (grams) = 21.129
Resistance (ohm) = 1.579
Cold MCP per TE Device (Watt sec/C) = 0.37528E+02
Hot MCP per TE Device (Watt sec/C) = 0.26973E+03
Cold, Hot, Interstage Conductivity (Watt/Sq in/C) = 6.3, 6.3, 20.0

TE Material	COMM	COMM
Couple Distribution	70.00	31.00
Pellet Width (inch)	0.0550	0.0850
Pellet Length (inch)	0.0630	0.1510
Stage Area (Square inch)	1.4400	1.4400
Alumina Thickness (inch)	0.0300	0.0300
Bus Bar Thickness (inch)	0.0150	0.0320

Exchanger Factor	Hot	Cold
Fluid Type	Water	
Plate Temperature (°K)	297.54	219.83
Inlet Temperature (°K)	291.00	
Outlet Temperature (°K)	295.64	219.83
Heat Out of Fluid (Watt)	-1223.49	0.00
Plate to Plate Loss (Watt)	15.22	15.22
Prandtl Number	7.07451	
Reynolds Number	58.63	0.00
Nusselt Number	6.4963	
Heat Transfer Coefficient	127.9112	
Pressure Drop (in H_2O)	0.1087	0.0000
Bend Factor (in H_2O)	0.0013	0.0000
Flow Rate (lb/hr)	500.00	0.00
Exchanger Weight (Lb)	41.75	11.60
Fin Length (inches)	12.000	12.000
Fin Height (inches)	1.205	0.510
Fin Thickness (inches)	0.015	0.015
Number of Fins	32.00	32.00
Fin Epsilon	0.70948	

TABLE 6.4.2 11/12/76

SYSTEM PERFORMANCE DESCRIPTION
54 TE UNITS, MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

Thermoelectric Device Physical Description

Height (inch) = 0.4300, Weight (gram) = 21.129, Resistance (ohm) = 1.579
Cold MCP per TE Device (Watt Sec/C) = 0.55448E+02
Hot MCP per TE Device (Watt Sec/C) = 0.26973E+03
Cold, Hot, Interstage Conductivity (Watt/sq in/C) = 6.3, 6.3, 20.0

TE Material	COMM	COMM
Couple Distribution	70.00	31.00
Pellet Width (inch)	0.0550	0.0850
Pellet Length (inch)	0.0630	0.1510
Stage Area (Square inch)	1.4400	1.4400
Alumina Thickness (inch)	0.0300	0.0300
Bus Bar Thickness (inch)	0.0150	0.0320

Exchanger Factor	Hot	Cold
Fluid Type	Water	60%EG
Plate Temperature (°K)	297.46	237.41
Inlet Temperature (°K)	290.40	239.54
Outlet Temperature (°K)	295.41	237.88
Heat Out of Fluid (Watt)	-1321.18	140.84
Plate to Plate Loss (Watt)	11.76	11.76
Prandtl Number	7.15441	634.70589
Reynolds Number	58.04	1.30
Nusselt Number	6.4964	5.1570
Heat Transfer Coefficient	127.7608	77.8288
Pressure Drop (in H_2O)	0.1098	24.1420
Bend Factor (in H_2O)	0.0013	0.0065
Flow Rate (lb/hr)	500.00	250.00
Exchanger Weight (lb)	41.75	11.60
Fin Length (inches)	12.000	12.000
Fin Height (inches)	1.205	0.510
Fin Thickness (inches)	0.015	0.015
Number of Fins	32.00	32.00
Fin Epsilon	0.70924	0.77939

(Table 6.4.2 Continued)

Table 6.4.2 (Continued)

<u>Reservoir Characteristics</u>

Ambient Temperature (°K)	297.09
Res Temperature (°K)	239.54
MCP (Watt Min/C)	2650.0
Loss Cond (Watt/C)	0.4859
Q Loss (Watt)	43.56

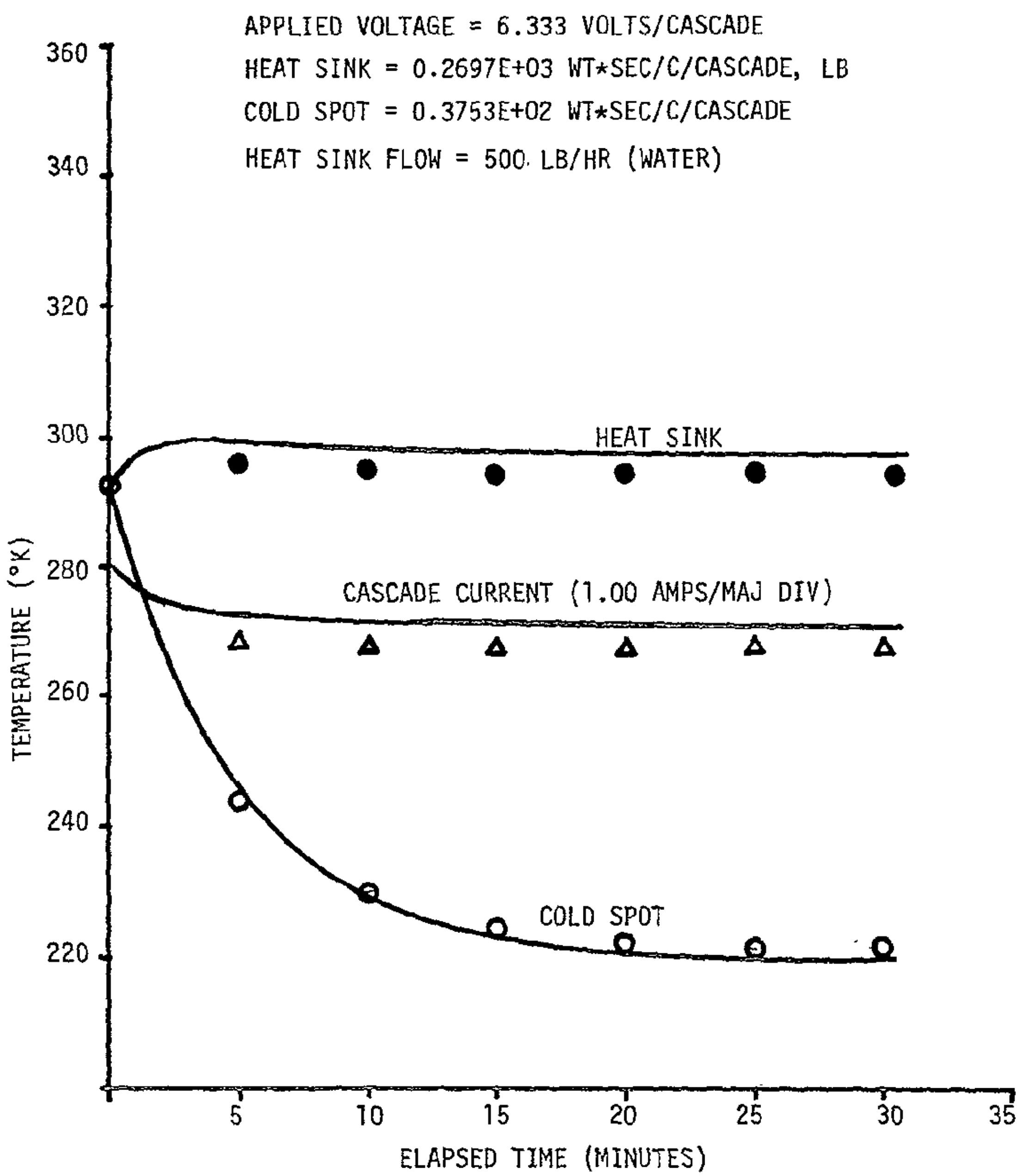


FIGURE 6.4.1 Zero Load ΔT Transient Performance

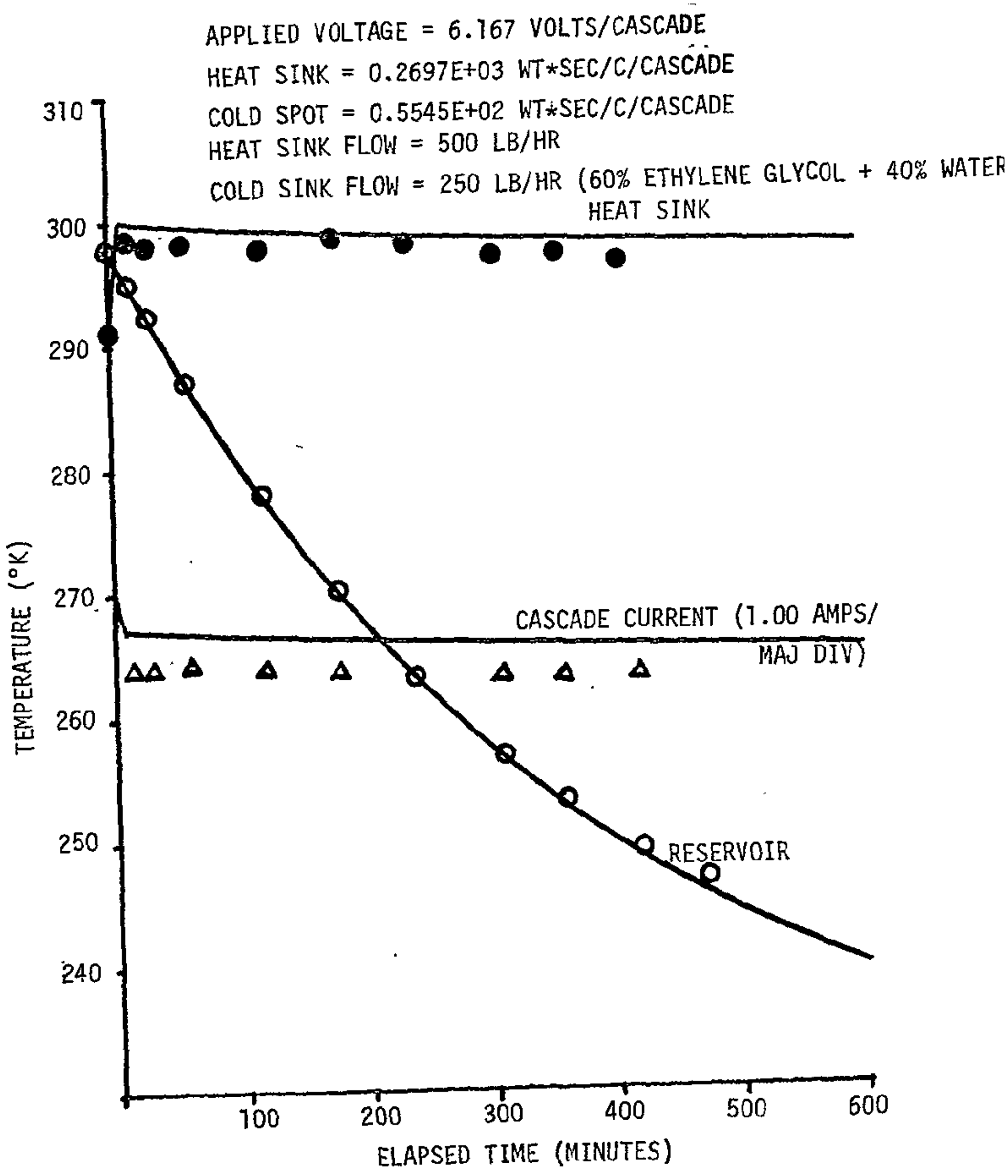


FIGURE 6.4.2 System Transient Performance

is expected to be present in these calculations.

The following set of input parameters were used:

Cold Inlet Temperature: 0°F (255.4°K), 35°F (274.9°K), 70°F (294.3°K)

Hot Flow Rate: 100, 300, 500 lb/hr.

Cold Flow Rate: 100, 150, 200, 300, 500, 700 lb/hr.

Hot Inlet Temperature: 70°F (294.3°K)

Applied Voltage: 18.5 volts

The resulting system parameters for each combination of the above input parameters are given in the appendix. The most important output parameter, cold outlet temperature, is illustrated in Figure 6.5.1. It was plotted as the inverse of the cold flow rate because of the nearly linear dependence, as observed.

PERFORMANCE PREDICTION

Heat Sink Inlet = 70°F

Applied Voltage = 18.5 volts

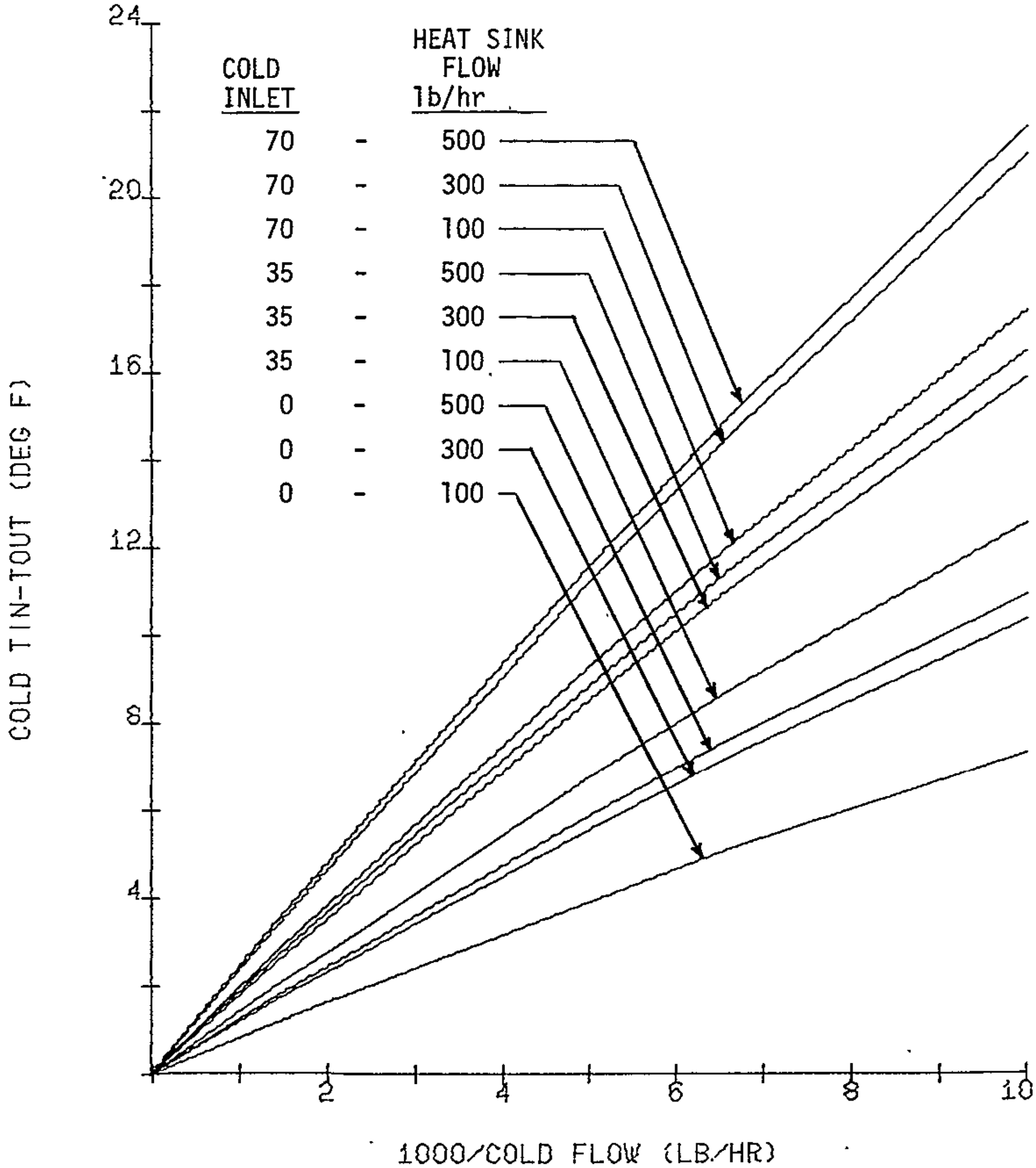


FIGURE 6.5.1

7. CONCLUSIONS

The first three conceptual phases of this program involved the thermal control of a cloud physics expansion chamber by attaching thermoelectric devices directly onto the chamber. The initial concept was based on a very optimistic input from the space lab heat exchanger. The subsequent two concepts both provided technically feasible system approaches to meet all contractual requirements. Indeed, the third phase was initiated as per MSFC's request solely for the purpose of improving cool down speed -- a parameter not specified in the contract.

Near the conclusion of the third phase, BWTE was informed of a specific transient requirement. Simple calculations using this requirement plus the mass of the chamber revealed that the transient condition could not be met on a real time basis using thermoelectrics. The limiting factor was the thermoelectric cooling "efficiency" limitation at the specified temperature conditions. This resulted in a complete redirection of effort and a fourth and final phase of activity.

A thermoelectric chiller unit was proposed to cool a liquid reservoir to -30°C for use in the thermal control of the chamber. A corresponding contract modification was made altering the scope of effort. A thermal model was generated and the resulting chiller was designed, fabricated, tested, and delivered. This unit met all requirements of the modified contract. The accuracy of the thermal model was validated and used for parametric study of system variables.

APPENDIX

Performance Calculations

(See Figure 6.5)

Input Parameters Varied:

1) Cold Inlet Temperature: 0°F (255.4°K), 35°F (274.9°K), 70°F (294.3°K)
2) Hot Flow Rate: 100, 300, 500 lb/hr.
3) Cold Flow Rate: 100, 150, 200, 300, 500, 700 lb/hr.

Input Parameters Constant:

1) Hot Inlet Temperature: 70°F (294.3°K)
2) Applied Voltage: 18.5 volts

T_C inlet = 0°F = 255.4°K

SYSTEM PERFORMANCE DESCRIPTION DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	316.77	251.19
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	316.73	251.32
HT OUT OF FLO(W)	-1182.91	144.88
PLT-PLT LOSS (W)	12.85	12.85
PRANDTL NUMBER	5.22663	231.32274
REYNOLDS NUMBER	15.33	1.50
NUSSELT NUMBER	6.3440	5.0151
HEAT TRNSFR COEF	129.3271	75.0602
PRSS DRP(IN H2O)	0.0165	3.3508
BEND FTR(IN H2O)	0.0001	0.0010
FLOW RT (LB/HR)	100.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99801	0.96944

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	56.408
POWER (WATTS)	1043.539

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	316.72	252.21
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	316.67	252.52
HT OUT OF FLD(W)	-1179.86	153.72
PLT-PLT LOSS (W)	12.63	12.63
PRANDTL NUMBER	5.23048	223.14757
REYNOLDS NUMBER	15.32	2.34
NUSSELT NUMBER	6.3440	5.0759
HEAT TRNSFR COEF	129.3156	75.9451
PRSS DRP(IN H2O)	0.0165	4.8408
BEND FTR(IN H2O)	0.0001	0.0024
FLOW RT (LB/HR)	100.00	150.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99801	0.90437

STEADY-STATE SYSTEM POWER CONDITIONS	
VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	56.529
POWER (WATTS)	1045.785

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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77   1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION .

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	317.22	252.79
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	317.17	253.23
HT OUT OF FLD(W)	-1206.15	154.25
PLT-PLT LOSS (W)	12.62	12.62
PRANDTL NUMBER	5.19916	218.43366
REYNOLDS NUMBER	15.40	3.19
NUSSELT NUMBER	6.3440	5.1347
HEAT TRNSFR COEF	129.4096	76.8111
PRSS DRP(IN H2O)	0.0164	6.3125
BEND FTR(IN H2O)	0.0001	0.0042
FLOW RT (LB/HR)	100.00	200.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99801	0.83095

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	56.373
POWER (WATTS)	1042.897

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	316.99	253.27
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	316.94	253.90
HT OUT OF FLD(W)	-1194.14	159.91
PLT-PLT LOSS (W)	12.48	12.48
PRANDTL NUMBER	5.21386	214.15346
REYNOLDS NUMBER	15.36	4.88
NUSSELT NUMBER	6.3440	5.2464
HEAT TRNSFR COEF	129.3654	78.4666
PRSS DRP(IN H2O)	0.0165	9.2773
BEND FTR(IN H2O)	0.0001	0.0094
FLOW RT (LB/HR)	100.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99801	0.70118

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	56.516
POWER (WATTS)	1045.539

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            SYSTEM PERFORMANCE DESCRIPTION       DATE 01/20/77  1237
          54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

                THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
   HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
   COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
    HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
   COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

          T.E. MATERIAL        COMM       COMM
     COUPLE DISTRIBUTION=      70.00      31.00
    PELLET  WIDTH (INCH)=     0.0550     0.0850
    PELLET LENGTH (INCH)=     0.0630     0.1510
    STAGE AREA (SQ INCH)=     1.4400     1.4400
    ALUMINA THKNS (INCH)=     0.0300     0.0300
    BUS-BAR THKNS (INCH)=     0.0150     0.0320

   EXCHANGER FACTOR        HOT       COLD
        FLUID TYPE        WATER      60%EG
      PLATE TEMP (K)     317.01     253.67
      INLET TEMP (K)     294.30     255.40
    OUTLET TEMP (K)      316.96     254.49
   HT OUT OF FLD(W)    -1195.22     162.95
   PLT-PLT LOSS (W)       12.41      12.41
     PRANDTL NUMBER     5.21262 210.51846
    REYNOLDS NUMBER       15.37       8.29
     NUSSELT NUMBER      6.3440     5.4488
   HEAT TRNSFR COEF    129.3691    81.4804
   PRSS DRP(IN H2O)      0.0165    15.1972
   BEND FTR(IN H2O)      0.0001     0.0261
   FLOW RT (LB/HR)       100.00     500.00
   EXCH WEIGHT (LB)       41.75      11.60
    FIN LENGTH (IN)      12.000     12.000
    LVR LENGTH (IN)      12.000     12.000
    FIN HEIGHT (IN)       1.205      0.510
    FIN THKNSS (IN)       0.015      0.015
     NUMBER OF FINS       32.00      32.00
        FIN EPSILON     0.99801    0.52775


    STEADY-STATE SYSTEM POWER CONDITIONS
         VOLTAGE (VOLTS)     18.500
          CURRENT (AMPS)     56.545
           POWER (WATTS)   1046.079
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         SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
       54 TE UNITS MODEL NO. CX952-70-31
WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

              THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
 HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

        T.E. MATERIAL      COMM      COMM
   COUPLE DISTRIBUTION=    70.00     31.00
  PELLET  WIDTH (INCH)=   0.0550    0.0850
  PELLET LENGTH (INCH)=   0.0630    0.1510
  STAGE AREA (SQ INCH)=   1.4400    1.4400
  ALUMINA THKNS (INCH)=   0.0300    0.0300
  BUS-BAR THKNS (INCH)=   0.0150    0.0320

EXCHANGER FACTOR       HOT      COLD
      FLUID TYPE      WATER     60%EG
   PLATE TEMP (K)    317.39    253.87
   INLET TEMP (K)    294.30    255.40
  OUTLET TEMP (K)    317.35    254.75
 HT OUT OF FLO(W)  -1215.47    161.81
 PLT-PLT LOSS (W)     12.44     12.44
   PRANDTL NUMBER   5.18865 208.88056
  REYNOLDS NUMBER     15.43     11.70
   NUSSELT NUMBER    6.3440    5.6295
 HEAT TRNSFR COEF  129.4413   84.1771
 PRSS DRP(IN H2O)    0.0164   21.1168
 BEND FTR(IN H2O)    0.0001    0.0512
  FLOW RT (LB/HR)    100.00    700.00
 EXCH WEIGHT (LB)     41.75     11.60
  FIN LENGTH (IN)    12.000    12.000
  LVR LENGTH (IN)    12.000    12.000
  FIN HEIGHT (IN)     1.205     0.510
  FIN THKNSS (IN)     0.015     0.015
   NUMBER OF FINS     32.00     32.00
      FIN EPSILON   0.99802   0.42437


  STEADY-STATE SYSTEM POWER CONDITIONS
       VOLTAGE (VOLTS)     18.500
        CURRENT (AMPS)     56.403
          POWER (WATTS)  1043.447
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	304.05	249.47
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	302.82	249.65
HT OUT OF FLU(W)	-1347.35	203.67
PLT-PLT LOSS (W)	10.69	10.69
PRANDTL NUMBER	6.17518	243.35095
REYNOLDS NUMBER	39.70	1.42
NUSSELT NUMBER	6.4173	5.0145
HEAT TRNSFR COEF	128.2758	75.0859
PRSS DRP(IN H2O)	0.0576	3.5338
BEND FTR(IN H2O)	0.0005	0.0010
FLOW RT (LB/HR)	300.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87299	0.96972

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	61.564
POWER (WATTS)	1138.932

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	304.10	250.92
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	302.85	251.35
HT OUT OF FLD(W)	-1353.25	215.63
PLT-PLT LOSS (W)	10.41	10.41
PRANDTL NUMBER	6.17334	231.11472
REYNOLDS NUMBER	39.71	2.25
NUSSELT NUMBER	6.4173	5.0752
HEAT TRNSFR COEF	128.2801	75.9597
PRSS DRP(IN H2O)	0.0576	5.0222
BEND FTR(IN H2O)	0.0005	0.0024
FLOW RT (LB/HR)	400.00	150.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87300	0.90477

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	61.681
POWER (WATTS)	1141.103

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	304.19	251.67
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	302.94	252.30
HT OUT OF FLD(W)	-1366.53	220.51
PLT-PLT LOSS (W)	10.29	10.29
PRANDTL NUMBER	6.16579	224.59921
REYNOLDS NUMBER	39.75	3.10
NUSSELT NUMBER	6.4173	5.1340
HEAT TRNSFR COEF	128.2978	76.8199
PRSS DRP(IN H2O)	0.0575	6.4995
BEND FTR(IN H2O)	0.0005	0.0042
FLOW RT (LB/HR)	300.00	200.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87302	0.83137

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	61.700
POWER (WATTS)	1141.447

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	304.24	252.38
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	302.98	253.28
HT OUT OF FLD(W)	-1372.79	225.92
PLT-PLT LOSS (W)	10.16	10.16
PRANDTL NUMBER	6.16278	218.10911
REYNOLDS NUMBER	39.77	4.79
NUSSELT NUMBER	6.4173	5.2456
HEAT TRNSFR COEF	128.3048	78.4685
PRSS DRP(IN H2O)	0.0575	9.4570
BEND FTR(IN H2O)	0.0005	0.0094
FLOW RT (LB/HR)	300.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87303	0.70149

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	61.745
POWER (WATTS)	1142.277

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          SYSTEM PERFORMANCE DESCRIPTION     DATE 01/20/77  1237
        54 TE UNITS MODEL NO. CX952-70-31
  WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

            THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
  HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
  COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
   HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
  COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

          T.E. MATERIAL        COMM       COMM
     COUPLE DISTRIBUTION=      70.00      31.00
    PELLET  WIDTH (INCH)=     0.0550     0.0850
    PELLET LENGTH (INCH)=     0.0630     0.1510
    STAGE AREA (SQ INCH)=     1.4400     1.4400
    ALUMINA THKNS (INCH)=     0.0300     0.0300
    BUS-BAR THKNS (INCH)=     0.0150     0.0320

  EXCHANGER FACTOR      HOT        COLD
        FLUID TYPE      WATER      60%EG
     PLATE TEMP (K)    304.27     252.95
     INLET TEMP (K)    294.30     255.40
    OUTLET TEMP (K)    303.00     254.11
   HT OUT OF FLD(W)  -1376.98     230.41
   PLT-PLT LOSS (W)     10.05      10.05
     PRANDTL NUMBER   6.16077 212.87389
    REYNOLDS NUMBER     39.78       8.19
     NUSSELT NUMBER    6.4173     5.4480
   HEAT TRNSFR COEF  128.3095    81.4769
   PRSS DRP(IN H2O)    0.0575    15.3754
   BEND FTR(IN H2O)    0.0005     0.0261
    FLOW RT (LB/HR)    300.00     500.00
   EXCH WEIGHT (LB)     41.75      11.60
    FIN LENGTH (IN)    12.000     12.000
    LVR LENGTH (IN)    12.000     12.000
    FIN HEIGHT (IN)     1.205      0.510
    FIN THKNSS (IN)     0.015      0.015
     NUMBER OF FINS     32.00      32.00
        FIN EPSILON   0.87303    0.52792


    STEADY-STATE SYSTEM POWER CONDITIONS
         VOLTAGE (VOLTS)      18.500
          CURRENT (AMPS)      61.782
           POWER (WATTS)    1142.973
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          SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
        54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

               THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
   HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
   COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
    HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
   COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

          T.E. MATERIAL      COMM      COMM
     COUPLE DISTRIBUTION=    70.00     31.00
    PELLET  WIDTH (INCH)=   0.0550    0.0850
    PELLET LENGTH (INCH)=   0.0630    0.1510
    STAGE AREA (SQ INCH)=   1.4400    1.4400
    ALUMINA THKNS (INCH)=   0.0300    0.0300
    BUS-BAR THKNS (INCH)=   0.0150    0.0320

   EXCHANGER FACTOR      HOT       COLD
         FLUID TYPE     WATER      60%EG
      PLATE TEMP (K)    304.29    253.21
      INLET TEMP (K)    294.30    255.40
    OUTLET TEMP (K)     303.02    254.47
   HT OUT OF FLD(W)   -1379.84    232.20
   PLT-PLT LOSS (W)      10.01     10.01
     PRANDTL NUMBER    6.15935 210.61755
    REYNOLDS NUMBER      39.79     11.60
     NUSSELT NUMBER     6.4173    5.6287
   HEAT TRNSFR COEF   128.3129   84.1711
   PRSS DRP(IN H2O)     0.0575   21.3007
   BEND FTR(IN H2O)     0.0005    0.0512
    FLOW RT (LB/HR)     300.00    700.00
   EXCH WEIGHT (LB)      41.75     11.60
    FIN LENGTH (IN)     12.000    12.000
    LVR LENGTH (IN)     12.000    12.000
    FIN HEIGHT (IN)      1.205     0.510
    FIN THKNSS (IN)      0.015     0.015
     NUMBER OF FINS      32.00     32.00
        FIN EPSILON    0.87304   0.42447

    STEADY-STATE SYSTEM POWER CONDITIONS
         VOLTAGE (VOLTS)    18.500
          CURRENT (AMPS)    61.796
            POWER (WATTS) 1143.224
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1708
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION*
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	301.64	249.14
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	299.52	249.33
HT OUT OF FLD(W)	-1377.02	214.77
PLT-PLT LOSS (W)	10.28	10.28
PRANDTL NUMBER	6.43784	245.72185
REYNOLDS NUMBER	63.76	1.41
NUSSELT NUMBER	6.4947	5.0144
HEAT TRNSFR COEF	129.2126	75.0908
PRSS DRP(IN H2O)	0.1000	3.5699
BEND FTR(IN H2O)	0.0013	0.0010
FLOW RT (LB/HR)	500.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71157	0.96978

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.581
POWER (WATTS)	1157.754

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1240
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	301.69	250.67
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	299.56	251.12
HT OUT OF FLD(W)	-1386.90	227.67
PLT-PLT LOSS (W)	9.99	9.99
PRANDTL NUMBER	6.43520	232.72792
REYNOLDS NUMBER	63.78	2.24
NUSSELT NUMBER	6.4947	5.0751
HEAT TRNSFR COEF	129.2184	75.9625
PRSS DRP(IN H2O)	0.1000	5.0590
BEND FTR(IN H2O)	0.0013	0.0024
FLOW RT (LB/HR)	500.00	150.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71158	0.90485

STEADY-STATE SYSTEM POWER CONDITIONS	
VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.697
POWER (WATTS)	1159.889

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SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1109
54 TE UNITS MODEL NO. CX952-70-31
RED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
IGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
LD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
UT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
LD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
ELLET WIDTH (INCH)=	0.0550	0.0850
ELLET LENGTH (INCH)=	0.0630	0.1510
TAGE AREA (SQ INCH)=	1.4400	1.4400
LUMINA THKNS (INCH)=	0.0300	0.0300
US-BAR THKNS (INCH)=	0.0150	0.0320

CHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	301.73	251.46
INLET TEMP (K)	294.30	255.40
UTLET TEMP (K)	299.59	252.12
OUT OF FLD(W)	-1394.99	233.10
T-PLT LOSS (W)	9.85	9.85
PRANDTL NUMBER	6.43274	225.83087
EYNOLDS NUMBER	63.81	3.08
NUSSELT NUMBER	6.4947	5.1339
AT TRNSFR COEF	129.2238	76.8216
SS DRP(IN H2O)	0.1000	6.5369
ND FTR(IN H2O)	0.0013	0.0042
LOW RT (LB/HR)	500.00	200.00
CH WEIGHT (LB)	41.75	11.60
IN LENGTH (IN)	12.000	12.000
VR LENGTH (IN)	12.000	12.000
IN HEIGHT (IN)	1.205	0.510
IN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71159	0.83145

TEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.748
POWER (WATTS)	1160.831

SYSTEM PERFORMANCE DESCRIPTION DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	301.78	252.22
INLET TEMP (K)	294.30	255.40
OUTLET TEMP (K)	299.63	253.17
HT OUT OF FLD(W)	-1404.42	238.48
PLT-PLT LOSS (W)	9.71	9.71
PRANDTL NUMBER	6.42933	218.87123
REYNOLDS NUMBER	63.84	4.77
NUSSELT NUMBER	6.4947	5.2455
HEAT TRNSFR COEF	129.2313	78.4689
PRSS DRP(IN H20)	0.0999	9.4917
BEND FTR(IN H20)	0.0013	0.0094
FLOW RT (LB/HR)	500.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71160	0.70155

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.790
POWER (WATTS)	1161.607

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SYSTEM PERFORMANCE DESCRIPTION     DATE 01/20/77  1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
 HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

         T.E. MATERIAL       COMM       COMM
   COUPLE DISTRIBUTION=     70.00      31.00
  PELLET  WIDTH (INCH)=    0.0550     0.0850
  PELLET LENGTH (INCH)=    0.0630     0.1510
  STAGE AREA (SQ INCH)=    1.4400     1.4400
  ALUMINA THKNS (INCH)=    0.0300     0.0300
  BUS-BAR THKNS (INCH)=    0.0150     0.0320

EXCHANGER FACTOR        HOT        COLD
      FLUID TYPE       WATER       60%EG
   PLATE TEMP (K)      301.81     252.82
   INLET TEMP (K)      294.30     255.40
  OUTLET TEMP (K)      299.65     254.04
HT OUT OF FLD(W)     -1409.57     243.04
PLT-PLT LOSS (W)         9.60       9.60
  PRANDTL NUMBER      6.42774  213.31674
 REYNOLDS NUMBER        63.85       8.17
  NUSSELT NUMBER       6.4947     5.4478
HEAT TRNSFR COEF     129.2348    81.4762
PRSS DRP(IN H2O)       0.0999    15.4089
BEND FTR(IN H2O)       0.0013     0.0261
 FLOW RT (LB/HR)       500.00     500.00
EXCH WEIGHT (LB)        41.75      11.60
 FIN LENGTH (IN)       12.000     12.000
 LVR LENGTH (IN)       12.000     12.000
 FIN HEIGHT (IN)        1.205      0.510
 FIN THKNSS (IN)        0.015      0.015
  NUMBER OF FINS        32.00      32.00
     FIN EPSILON      0.71160    0.52795

 STEADY-STATE SYSTEM POWER CONDITIONS
      VOLTAGE (VOLTS)     18.500
       CURRENT (AMPS)     62.831
        POWER (WATTS)   1162.369
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          SYSTEM PERFORMANCE DESCRIPTION        DATE 01/20/77   1237
        54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF    3 UNITS IN SERIES

                THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
   HEIGHT (INCH)= 0.4300    WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
   COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
    HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
   COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

             T.E. MATERIAL        COMM        COMM
     COUPLE DISTRIBUTION=        70.00       31.00
    PELLET  WIDTH (INCH)=       0.0550      0.0850
    PELLET LENGTH (INCH)=       0.0630      0.1510
    STAGE AREA (SQ INCH)=       1.4400      1.4400
    ALUMINA THKNS (INCH)=       0.0300      0.0300
    BUS-BAR THKNS (INCH)=       0.0150      0.0320

   EXCHANGER FACTOR        HOT        COLD
         FLUID TYPE       WATER       60%EG
     PLATE TEMP (K)      301.83      253.08
     INLET TEMP (K)      294.30      255.40
    OUTLET TEMP (K)      299.66      254.42
   HT OUT OF FLD(W)    -1412.64      245.27
   PLT-PLT LOSS (W)        9.55        9.55
     PRANDTL NUMBER     6.42661   210.93621
    REYNOLDS NUMBER       63.86       11.58
     NUSSELT NUMBER      6.4947      5.6285
   HEAT TRNSFR COEF    129.2373     84.1700
   PRSS DRP(IN H2O)      0.0999     21.3344
   BEND FTR(IN H2O)      0.0013      0.0512
    FLOW RT (LB/HR)      500.00      700.00
   EXCH WEIGHT (LB)       41.75       11.60
    FIN LENGTH (IN)      12.000      12.000
    LVR LENGTH (IN)      12.000      12.000
    FIN HEIGHT (IN)       1.205       0.510
    FIN THKNSS (IN)       0.015       0.015
     NUMBER OF FINS       32.00       32.00
        FIN EPSILON     0.71161     0.42449

    STEADY-STATE SYSTEM POWER CONDITIONS
         VOLTAGE (VOLTS)     18.500
          CURRENT (AMPS)     62.846
            POWER (WATTS)  1162.652
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T_c inlet = 35°F = 274.9°K

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	319.22	267.66
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	319.17	267.92
HT OUT OF FLD(W)	-1311.66	259.25
PLT-PLT LOSS (W)	10.10	10.10
PRANDTL NUMBER	5.08255	91.38002
REYNOLDS NUMBER	15.71	4.01
NUSSELT NUMBER	6.3439	5.0266
HEAT TRNSFR COEF	129.7670	74.4676
PRSS DRP(IN H2O)	0.0161	1.2625
BEND FTR(IN H2O)	0.0001	0.0011
FLOW RT (LB/HR)	100.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99803	0.96346

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	56.962
POWER (WATTS)	1053.802

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	319.22	269.41
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	319.18	270.00
HT OUT OF FLD(W)	-1311.94	273.43
PLT-PLT LOSS (W)	9.76	9.76
PRANDTL NUMBER	5.08261	87.36576
REYNOLDS NUMBER	15.71	6.32
NUSSELT NUMBER	6.3439	5.0949
HEAT TRNSFR COEF	129.7668	75.4309
PRSS DRP(IN H2O)	0.0161	1.8068
BEND FTR(IN H2O)	0.0001	0.0024
FLOW RT (LB/HR)	100.00	150.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99803	0.89224

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.125
POWER (WATTS)	1056.811

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1109
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	319.30	270.30
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	319.25	271.15
HT OUT OF FLD(W)	-1315.74	279.81
PLT-PLT LOSS (W)	9.60	9.60
PRANDTL NUMBER	5.07845	85.26795
REYNOLDS NUMBER	15.72	8.65
NUSSELT NUMBER	6.3439	5.1615
HEAT TRNSFR COEF	129.7798	76.3905
PRSS DRP(IN H2O)	0.0161	2.3491
BEND FTR(IN H2O)	0.0001	0.0042
FLOW RT (LB/HR)	100.00	200.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99603	0.81525

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.178
POWER (WATTS)	1057.795

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              SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
           54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

                 THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
   HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
   COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
    HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
   COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

             T.E. MATERIAL       COMM       COMM
     COUPLE DISTRIBUTION=       70.00      31.00
    PELLET  WIDTH (INCH)=      0.0550     0.0850
    PELLET LENGTH (INCH)=      0.0630     0.1510
    STAGE AREA (SQ INCH)=      1.4400     1.4400
    ALUMINA THKNS (INCH)=      0.0300     0.0300
    BUS-BAR THKNS (INCH)=      0.0150     0.0320

   EXCHANGER FACTOR        HOT       COLD
         FLUID TYPE       WATER      60%EG
     PLATE TEMP (K)       319.54     271.18
     INLET TEMP (K)       294.30     274.90
    OUTLET TEMP (K)       319.49     272.36
   HT OUT OF FLU(W)     -1328.70     284.78
   PLT-PLT LOSS (W)         9.47       9.47
     PRANDTL NUMBER      5.06395   53.12381
    REYNOLDS NUMBER        15.76      13.33
     NUSSELT NUMBER       6.3439     5.2891
   HEAT TRNSFR COEF     129.8251    78.2492
   PRSS DRP(IN H2O)       0.0161     3.4333
   BEND FTR(IN H2O)       0.0001     0.0095
   FLOW RT (LB/HR)        100.00     300.00
   EXCH WEIGHT (LB)        41.75      11.60
     FIN LENGTH (IN)      12.000     12.000
    LVR LENGTH (IN)       12.000     12.000
    FIN HEIGHT (IN)        1.205      0.510
    FIN THKNSS (IN)        0.015      0.015
     NUMBER OF FINS        32.00      32.00
        FIN EPSILON      0.99804    0.68337


    STEADY-STATE SYSTEM POWER CONDITIONS
         VOLTAGE (VOLTS)     18.500
           CURRENT (AMPS)    57.160
             POWER (WATTS)  1057.468
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	319.96	271.90
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	319.91	273.36
HT OUT OF FLU(W)	-1350.79	287.26
PLT-PLT LOSS (W)	9.42	9.42
PRANDTL NUMBER	5.03919	81.40005
REYNOLDS NUMBER	15.83	22.71
NUSSELT NUMBER	6.3439	5.5231
HEAT TRNSFR COEF	129.9030	81.6866
PRSS DRP(IN H2O)	0.0160	5.6073
BEND FTR(IN H2O)	0.0001	0.0264
FLOW RT (LB/HR)	100.00	500.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99804	0.51209

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.057
POWER (WATTS)	1055.553

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          SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
        54 TE UNITS MODEL NO. CX952-70-31
WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

              THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
 HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

         T.E. MATERIAL        COMM       COMM
  COUPLE DISTRIBUTION=       70.00      31.00
 PELLET  WIDTH (INCH)=      0.0550     0.0850
 PELLET LENGTH (INCH)=      0.0630     0.1510
 STAGE AREA (SQ INCH)=      1.4400     1.4400
 ALUMINA THKNS (INCH)=      0.0300     0.0300
 BUS-BAR THKNS (INCH)=      0.0150     0.0320

EXCHANGER FACTOR        HOT        COLD
     FLUID TYPE        WATER       60%FG
  PLATE TEMP (K)       319.64      272.19
  INLET TEMP (K)       294.30      274.90
 OUTLET TEMP (K)       319.59      273.78
HT OUT OF FLD(W)     -1333.98      291.95
PLT-PLT LOSS (W)         9.29        9.29
  PRANDTL NUMBER      5.05821    80.69266
 REYNOLDS NUMBER        15.78       32.09
  NUSSELT NUMBER       6.3439      5.7344
HEAT TRNSFR COEF     129.8431     84.7991
PRSS DRP(IN H2O)       0.0160      7.7926
BEND FTR(IN H2O)       0.0001      0.0517
FLOW RT (LB/HR)        100.00      700.00
EXCH WEIGHT (LB)        41.75       11.60
 FIN LENGTH (IN)       12.000      12.000
 LVR LENGTH (IN)       12.000      12.000
 FIN HEIGHT (IN)        1.205       0.510
 FIN THKNSS (IN)        0.015       0.015
  NUMBER OF FINS        32.00       32.00
     FIN EPSILON      0.99804     0.41175


  STEADY-STATE SYSTEM POWER CONDITIONS
        VOLTAGE (VOLTS)     18.500
         CURRENT (AMPS)     57.214
          POWER (WATTS)   1058.467
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	305.08	265.75
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	303.71	266.08
HT OUT OF FLD(W)	-1488.61	326.90
PLT-PLT LOSS (W)	7.70	7.70
PRANDTL NUMBER	6.10671	95.13932
REYNOLDS NUMBER	40.09	3.85
NUSSELT NUMBER	6.4172	5.0261
HEAT TRNSFR COEF	128.4371	74.5006
PRSS DRP(IN H2O)	0.0571	1.3173
BEND FTR(IN H2O)	0.0005	0.0011
FLOW RT (LB/HR)	300.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87318	0.96376

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.572
POWER (WATTS)	1157.590

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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	305.13	267.97
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	303.76	268.72
HT OUT OF FLD(W)	-1496.48	344.83
PLT-PLT LOSS (W)	7.28	7.28
PRANDTL NUMBER	6.10404	89.81890
REYNOLDS NUMBER	40.11	6.13
NUSSELT NUMBER	6.4172	5.0943
HEAT TRNSFR COEF	128.4435	75.4514
PRSS DRP(IN H2O)	0.0570	1.8604
BEND FTR(IN H2O)	0.0005	0.0024
FLOW RT (LB/HR)	300.00	150.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87319	0.89265

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.751
POWER (WATTS)	1160.888

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SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
    54 TE UNITS MODEL NO. CX952-70-31
WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

           THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
 HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

          T.E. MATERIAL      COMM      COMM
  COUPLE DISTRIBUTION=      70.00     31.00
 PELLET  WIDTH (INCH)=     0.0550    0.0850
 PELLET LENGTH (INCH)=     0.0630    0.1510
 STAGE AREA (SQ INCH)=     1.4400    1.4400
 ALUMINA THKNS (INCH)=     0.0300    0.0300
 BUS-BAR THKNS (INCH)=     0.0150    0.0320

EXCHANGER FACTOR       HOT       COLD
      FLUID TYPE      WATER      60%EG
  PLATE TEMP (K)     305.28     269.10
  INLET TEMP (K)     294.30     274.90
 OUTLET TEMP (K)     303.89     270.17
HT OUT OF FLD(W)   -1517.03     352.06
PLT-PLT LOSS (W)       7.09       7.09
  PRANDTL NUMBER    6.09313   87.04656
 REYNOLDS NUMBER      40.17       8.46
 NUSSELT NUMBER      6.4172     5.1609
HEAT TRNSFR COEF   128.4694    76.4038
PRSS DRP(IN H2O)     0.0569     2.4008
BEND FTR(IN H2O)     0.0005     0.0042
 FLOW RT (LB/HR)     300.00     200.00
EXCH WEIGHT (LB)      41.75      11.60
 FIN LENGTH (IN)     12.000     12.000
 LVR LENGTH (IN)     12.000     12.000
 FIN HEIGHT (IN)      1.205      0.510
 FIN THKNSS (IN)      0.015      0.015
  NUMBER OF FINS      32.00      32.00
     FIN EPSILON    0.87322    0.81564

 STEADY-STATE SYSTEM POWER CONDITIONS
      VOLTAGE (VOLTS)     18.500
        CURRENT (AMPS)     62.782
         POWER (WATTS)   1161.460
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	305.35	270.19
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	303.95	271.68
HT OUT OF FLO(W)	-1526.28	360.24
PLT-PLT LOSS (W)	6.89	6.89
PRANDTL NUMBER	6.08871	84.31083
REYNOLDS NUMBER	40.20	13.13
NUSSELT NUMBER	6.4172	5.2884
HEAT TRNSFR COEF	128.4800	78.2552
PRSS DRP(IN H2O)	0.0569	3.4850
BEND FTR(IN H2O)	0.0005	0.0095
FLOW RT (LB/HR)	300.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87323	0.68367

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.849
POWER (WATTS)	1162.705

SYSTEM PERFORMANCE DESCRIPTION DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	305.40	271.07
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	303.99	272.94
HT OUT OF FLO(W)	-1533.84	366.64
PLT-PLT LOSS (W)	6.73	6.73
PRANDTL NUMBER	6.04511	82.12351
REYNOLDS NUMBER	40.22	22.50
NUSSELT NUMBER	6.4172	5.5224
HEAT TRNSFR COFF	128.4886	81.6862
PRSS DRP(IN H2O)	0.0569	5.6597
BEND FTR(IN H2O)	0.0005	0.0264
FLOW RT (LB/HR)	300.00	500.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87324	0.51225

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.903
POWER (WATTS)	1163.707

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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	305.42	271.47
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	304.01	273.49
HT OUT OF FLD(W)	-1536.86	369.52
PLT-PLT LOSS (W)	6.65	6.65
PRANDTL NUMBER	6.08372	81.18763
REYNOLDS NUMBER	40.22	31.89
NUSSELT NUMBER	6.4172	5.7336
HEAT TRNSFR COEF	128.4919	84.7960
PRSS DRP(IN H2O)	0.0569	7.8428
BEND FTR(IN H2O)	0.0005	0.0517
FLOW RT (LB/HR)	300.00	700.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87325	0.41184

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	62.929
POWER (WATTS)	1164.193

SYSTEM PERFORMANCE DESCRIPTION DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	302.40	265.39
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	300.07	265.74
HT OUT OF FLD(W)	-1520.96	339.50
PLT-PLT LOSS (W)	7.25	7.25
PRANDTL NUMBER	6.39313	95.86483
REYNOLDS NUMBER	64.16	3.82
NUSSELT NUMBER	6.4946	5.0260
HEAT TRNSFR COEF	129.3114	74.5067
PRSS DRP(IN H2O)	0.0994	1.3279
BEND FTR(IN H2O)	0.0013	0.0011
FLOW RT (LB/HR)	500.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71173	0.96382

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	63.678
POWER (WATTS)	1178.037

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SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1240
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	302.47	267.71
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	300.11	268.48
HT OUT OF FLD(W)	-1532.90	357.82
PLT-PLT LOSS (W)	6.81	6.81
PRANDTL NUMBER	6.39037	90.27314
REYNOLDS NUMBER	64.18	6.10
NUSSELT NUMBER	6.4946	5.0941
HEAT TRNSFR COEF	129.3176	75.4551
PRSS DRP(IN H20)	0.0994	1.8703
BEND FTR(IN H20)	0.0013	0.0024
FLOW RT (LB/HR)	500.00	150.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71174	0.89273

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	63.859
POWER (WATTS)	1181.397

SYSTEM PERFORMANCE DESCRIPTION DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	302.57	268.87
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	300.18	269.98
HT OUT OF FLD(W)	-1551.58	366.00
PLT-PLT LOSS (W)	6.60	6.60
PRANDTL NUMBER	6.38367	87.39790
REYNOLDS NUMBER	64.24	8.42
NUSSELT NUMBER	6.4946	5.1607
HEAT TRNSFR COEF	129.3325	76.4063
PRSS DRP(IN H2O)	0.0993	2.4110
BEND FTR(IN H2O)	0.0013	0.0042
FLOW RT (LB/HR)	500.00	200.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71176	0.81572

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	63.912
POWER (WATTS)	1182.368

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        SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
      54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

          THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
 HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
 COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
  HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
 COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

        T.E. MATERIAL       COMM      COMM
   COUPLE DISTRIBUTION=     70.00     31.00
  PELLET  WIDTH (INCH)=    0.0550    0.0850
  PELLET LENGTH (INCH)=    0.0630    0.1510
  STAGE AREA (SQ INCH)=    1.4400    1.4400
  ALUMINA THKNS (INCH)=    0.0300    0.0300
  BUS-BAR THKNS (INCH)=    0.0150    0.0320

 EXCHANGER FACTOR      HOT       COLD
      FLUID TYPE      WATER      60%EG
   PLATE TEMP (K)     302.62     270.01
   INLET TEMP (K)     294.30     274.90
  OUTLET TEMP (K)     300.22     271.55
 HT OUT OF FLD(W)   -1561.23     374.43
 PLT-PLT LOSS (W)       6.39       6.39
   PRANDTL NUMBER    6.38079   84.53804
  REYNOLDS NUMBER      64.27      13.09
   NUSSELT NUMBER     6.4946     5.2882
 HEAT TRNSFR COEF   129.3389    78.2563
 PRSS DRP(IN H20)     0.0992     3.4949
 BEND FTR(IN H20)     0.0013     0.0095
 FLOW RT (LB/HR)      500.00     300.00
 EXCH WEIGHT (LB)      41.75      11.60
  FIN LENGTH (IN)     12.000     12.000
  LVR LENGTH (IN)     12.000     12.000
  FIN HEIGHT (IN)      1.205      0.510
  FIN THKNSS (IN)      0.015      0.015
   NUMBER OF FINS      32.00      32.00
      FIN EPSILON    0.71177    0.68373

  STEADY-STATE SYSTEM POWER CONDITIONS
      VOLTAGE (VOLTS)     18.500
       CURRENT (AMPS)     63.989
        POWER (WATTS)   1183.792
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77   1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	302.66	270.91
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	300.25	272.86
HT OUT OF FLD(W)	-1569.40	381.28
PLT-PLT LOSS (W)	6.22	6.22
PRANDTL NUMBER	6.37821	82.25760
REYNOLDS NUMBER	64.29	22.46
NUSSELT NUMBER	6.4946	5.5222
HEAT TRNSFR COEF	129.3447	81.6861
PRSS DRP(IN H2O)	0.0992	5.6695
BEND FTR(IN H2O)	0.0013	0.0264
FLOW RT (LB/HR)	500.00	500.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71178	0.51228

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	64.048
POWER (WATTS)	1184.895

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/20/77 1237

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	302.68	271.33
INLET TEMP (K)	294.30	274.90
OUTLET TEMP (K)	300.27	273.43
HT OUT OF FLD(W)	-1572.99	384.51
PLT-PLT LOSS (W)	6.14	6.14
PRANDTL NUMBER	6.37709	81.28581
REYNOLDS NUMBER	64.30	31.84
NUSSELT NUMBER	6.4946	5.7335
HEAT TRNSFR COEF	129.3472	84.7954
PRSS DRP(IN H2O)	0.0992	7.8528
BEND FTR(IN H2O)	0.0013	0.0517
FLOW RT (LB/HR)	500.00	700.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71178	0.41186

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	64.077
POWER (WATTS)	1185.419

T_c inlet = 70°F = 294.3°K

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              SYSTEM PERFORMANCE DESCRIPTION      DATE 01/20/77  1237
            54 TE UNITS MODEL NO. CX952-70-31
     WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

                 THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
     HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
     COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
      HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
     COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

            T.E. MATERIAL       COMM       COMM
       COUPLE DISTRIBUTION=     70.00      31.00
      PELLET  WIDTH (INCH)=    0.0550     0.0850
      PELLET LENGTH (INCH)=    0.0630     0.1510
      STAGE AREA (SQ INCH)=    1.4400     1.4400
      ALUMINA THKNS (INCH)=    0.0300     0.0300
      BUS-BAR THKNS (INCH)=    0.0150     0.0320

     EXCHANGER FACTOR        HOT       COLD
           FLUID TYPE       WATER      60%EG
       PLATE TEMP (K)      321.47     284.20
       INLET TEMP (K)      294.30     294.30
      OUTLET TEMP (K)      321.42     284.63
     HT OUT OF FLD(W)    -1430.31     373.32
     PLT-PLT LOSS (W)        7.30       7.30
      PRANDTL NUMBER      4.95492   46.45921
     REYNOLDS NUMBER        16.06       8.31
      NUSSELT NUMBER       6.3438     5.0371
     HEAT TRNSFR COEF    130.1722    73.7017
     PRSS DRP(IN H2O)      0.0158     0.6158
     BEND FTR(IN H2O)      0.0001     0.0011
     FLOW RT (LB/HR)       100.00     100.00
     EXCH WEIGHT (LB)       41.75      11.60
      FIN LENGTH (IN)      12.000     12.000
      LVR LENGTH (IN)      12.000     12.000
      FIN HEIGHT (IN)       1.205      0.510
      FIN THKNSS (IN)       0.015      0.015
      NUMBER OF FINS        32.00      32.00
         FIN EPSILON      0.99806    0.95727

     STEADY-STATE SYSTEM POWER CONDITIONS
          VOLTAGE (VOLTS)     18.500
           CURRENT (AMPS)     57.603
            POWER (WATTS)   1065.647
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            SYSTEM PERFORMANCE DESCRIPTION      DATE 01/21/77  1240
          54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF    3 UNITS IN SERIES

                THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
   HEIGHT (INCH)= 0.4300    WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
   COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
    HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
   COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

            T.E. MATERIAL        COMM        COMM
     COUPLE DISTRIBUTION=        70.00       31.00
    PELLET  WIDTH (INCH)=       0.0550      0.0850
    PELLET LENGTH (INCH)=       0.0630      0.1510
    STAGE AREA (SQ INCH)=       1.4400      1.4400
    ALUMINA THKNS (INCH)=       0.0300      0.0300
    BUS-BAR THKNS (INCH)=       0.0150      0.0320

   EXCHANGER FACTOR        HOT        COLD
         FLUID TYPE       WATER       60%EG
     PLATE TEMP (K)      321.62      286.64
     INLET TEMP (K)      294.30      294.30
    OUTLET TEMP (K)      321.57      287.56
   HT OUT OF FLD(W)    -1438.09      391.44
   PLT-PLT LOSS (W)        6.85        6.85
     PRANDTL NUMBER     4.94702    44.32809
    REYNOLDS NUMBER       16.09       13.12
     NUSSELT NUMBER      6.3438      5.1121
   HEAT TRNSFR COEF    130.1977     74.7098
   PRSS DRP(IN H2O)      0.0157      0.8792
   BEND FTR(IN H2O)      0.0001      0.0024
    FLOW RT (LB/HR)      100.00      150.00
   EXCH WEIGHT (LB)       41.75       11.60
    FIN LENGTH (IN)      12.000      12.000
    LVR LENGTH (IN)      12.000      12.000
    FIN HEIGHT (IN)       1.205       0.510
    FIN THKNSS (IN)       0.015       0.015
     NUMBER OF FINS       32.00       32.00
        FIN EPSILON     0.99806     0.88027

    STEADY-STATE SYSTEM POWER CONDITIONS
         VOLTAGE (VOLTS)      18.500
          CURRENT (AMPS)      57.770
           POWER (WATTS)    1068.753
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1109

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	321.73	287.86
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	321.68	289.14
HT OUT OF FLD(W)	-1443.79	399.98
PLT-PLT LOSS (W)	6.63	6.63
PRANDTL NUMBER	4.94102	43.23466
REYNOLDS NUMBER	16.10	17.98
NUSSELT NUMBER	6.3438	5.1856
HEAT TRNSFR COEF	130.2172	75.7349
PRSS DRP(IN H2O)	0.0157	1.1423
BEND FTR(IN H2O)	0.0001	0.0043
FLOW RT (LB/HR)	100.00	200.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99806	0.80008

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.839
POWER (WATTS)	1070.018

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	321.88	289.05
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	321.82	290.80
HT OUT OF FLD(W)	-1451.62	408.02
PLT-PLT LOSS (W)	6.43	6.43
PRANDTL NUMBER	4.93279	42.13168
REYNOLDS NUMBER	16.13	27.74
NUSSELT NUMBER	6.3438	5.3271
HEAT TRNSFR COEF	130.2440	77.7485
PRSS DRP(IN H2O)	0.0157	1.6697
BEND FTR(IN H2O)	0.0001	0.0096
FLOW RT (LB/HR)	100.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99806	0.66651

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.890
POWER (WATTS)	1070.963

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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	321.89	290.01
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	321.83	292.17
HT OUT OF FLD(W)	-1452.13	415.33
PLT-PLT LOSS (W)	6.24	6.24
PRANDTL NUMBER	4.93226	41.25178
REYNOLDS NUMBER	16.13	47.32
NUSSELT NUMBER	6.3438	5.5888
HEAT TRNSFR COEF	130.2457	81.5211
PRSS DRP(IN H2O)	0.0157	2.7308
BEND FTR(IN H2O)	0.0001	0.0266
FLOW RT (LB/HR)	100.00	500.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99806	0.49736

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.973
POWER (WATTS)	1072.504

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	321.96	290.46
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	321.90	292.77
HT OUT OF FLD(W)	-1455.75	418.27
PLT-PLT LOSS (W)	6.17	6.17
PRANDTL NUMBER	4.92846	40.87334
REYNOLDS NUMBER	16.14	66.91
NUSSELT NUMBER	6.3438	5.8267
HEAT TRNSFR COEF	130.2581	84.9683
PRSS DRP(IN H20)	0.0157	3.8001
BEND FTR(IN H20)	0.0001	0.0522
FLOW RT (LB/HR)	100.00	700.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.99806	0.39978

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	57.988
POWER (WATTS)	1072.776

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SYSTEM PERFORMANCE DESCRIPTION DATE 01/20/77 1237
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	306.08	282.14
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	304.59	282.65
HT OUT OF FLD(W)	-1627.70	448.75
PLT-PLT LOSS (W)	4.69	4.69
PRANDTL NUMBER	6.04052	47.97960
REYNOLDS NUMBER	40.48	8.03
NUSSELT NUMBER	6.4171	5.0366
HEAT TRNSFR COEF	128.5957	73.7506
PRSS DRP(IN H2O)	0.0565	0.6374
BEND FTR(IN H2O)	0.0005	0.0011
FLOW RT (LB/HR)	300.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87337	0.95763

STEADY-STATE SYSTEM POWER CONDITIONS
VOLTAGE (VOLTS) 18.500
CURRENT (AMPS) 63.586
POWER (WATTS) 1176.341

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SYSTEM PERFORMANCE DESCRIPTION      DATE 01/21/77  1240
     54 TE UNITS MODEL NO. CX952-70-31
WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

            THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
 HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,  6.3,  20.0

        T.E. MATERIAL          COMM       COMM
  COUPLE DISTRIBUTION=         70.00      31.00
 PELLET  WIDTH (INCH)=        0.0550     0.0850
 PELLET LENGTH (INCH)=        0.0630     0.1510
 STAGE AREA (SQ INCH)=        1.4400     1.4400
 ALUMINA THKNS (INCH)=        0.0300     0.0300
 BUS-BAR THKNS (INCH)=        0.0150     0.0320

EXCHANGER FACTOR          HOT        COLD
      FLUID TYPE         WATER       60%EG
  PLATE TEMP (K)        306.18      285.07
  INLET TEMP (K)        294.30      294.30
 OUTLET TEMP (K)        304.68      286.17
HT OUT OF FLD(W)      -1641.70      471.44
PLT-PLT LOSS (W)          4.13        4.13
  PRANDTL NUMBER       6.03497    45.32122
 REYNOLDS NUMBER         40.51       12.81
  NUSSELT NUMBER        6.4171      5.1114
HEAT TRNSFR COEF      128.6091     74.7425
PRSS DRP(IN H2O)        0.0565      0.9003
BEND FTR(IN H2O)        0.0005      0.0024
 FLOW RT (LB/HR)        300.00      150.00
EXCH WEIGHT (LB)         41.75       11.60
 FIN LENGTH (IN)        12.000      12.000
 LVR LENGTH (IN)        12.000      12.000
 FIN HEIGHT (IN)         1.205       0.510
 FIN THKNSS (IN)         0.015       0.015
  NUMBER OF FINS         32.00       32.00
     FIN EPSILON       0.87338     0.88074

 STEADY-STATE SYSTEM POWER CONDITIONS
      VOLTAGE (VOLTS)      18.500
       CURRENT (AMPS)      63.804
        POWER (WATTS)    1180.380
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          SYSTEM PERFORMANCE DESCRIPTION      DATE 01/21/77  1109
        54 TE UNITS MODEL NO. CX952-70-31
WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

              THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

        T.E. MATERIAL        COMM       COMM
   COUPLE DISTRIBUTION=     70.00      31.00
  PELLET  WIDTH (INCH)=    0.0550     0.0850
  PELLET LENGTH (INCH)=    0.0630     0.1510
  STAGE AREA (SQ INCH)=    1.4400     1.4400
  ALUMINA THKNS (INCH)=    0.0300     0.0300
  BUS-BAR THKNS (INCH)=    0.0150     0.0320

EXCHANGER FACTOR       HOT       COLD
     FLUID TYPE        WATER      60%EG
   PLATE TEMP (K)     396.27     286.53
   INLET TEMP (K)     294.30     294.30
  OUTLET TEMP (K)     304.75     288.08
HT OUT OF FLD(W)    -1654.08     481.99
PLT-PLT LOSS (W)        3.86       3.86
   PRANDTL NUMBER     6.02414   43.96572
  REYNOLDS NUMBER      40.55      17.65
   NUSSELT NUMBER     6.4171     5.1849
HEAT TRNSFR COEF    125.5232    75.7582
PRSS DRP(IN H2O)      0.0564     1.1630
BEND FTR(IN H2O)      0.0005     0.0043
  FLOW RT (LB/HR)     400.00     200.00
EXCH WEIGHT (LB)       41.75      11.60
  FIN LENGTH (IN)     12.000     12.000
  LVR LENGTH (IN)     12.000     12.000
  FIN HEIGHT (IN)      1.205      0.510
  FIN THKNSS (IN)      0.015      0.015
   NUMBER OF FINS      32.00      32.00
      FIN EPSILON    0.87340    0.80053


 STEADY-STATE SYSTEM POWER CONDITIONS
       VOLTAGE (VOLTS)     18.500
        CURRENT (AMPS)     63.893
          POWER (WATTS)  1182.029
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SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1109

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	50%EG
PLATE TEMP (K)	306.36	287.96
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	304.84	290.07
HT OUT OF FLD(W)	-1667.23	492.25
PLT-PLT LOSS (W)	3.60	3.60
PRANDTL NUMBER	6.02295	42.61038
REYNOLDS NUMBER	40.58	27.40
NUSSELT NUMBER	6.4171	5.3264
HEAT TRNSFR COEF	128.6382	77.7616
PRSS DRP(IN H2O)	0.0564	1.6900
BEND FTR(IN H2O)	0.0005	0.0096
FLOW RT (LB/HR)	300.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	52.00	32.00
FIN EPSILON	0.87342	0.66685

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	63.978
POWER (WATTS)	1183.590

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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF   3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	306.39	289.12
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	304.86	291.72
HT OUT OF FLD(W)	-1670.86	501.12
PLT-PLT LOSS (W)	3.38	3.38
PRANDTL NUMBER	6.02124	41.53388
REYNOLDS NUMBER	40.59	46.96
NUSSELT NUMBER	6.4171	5.5881
HEAT TRNSFR COEF	128.6423	81.5254
PRSS DRP(IN H2O)	0.0564	2.7508
BEND FTR(IN H2O)	0.0005	0.0266
FLOW RT (LB/HR)	300.00	500.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87342	0.49754

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	64.067
POWER (WATTS)	1185.237

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3 6.3 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	306.42	289.66
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	304.89	292.45
HT OUT OF FLO(W)	-1675.27	505.06
PLT-PLT LOSS (W)	3.28	3.28
PRANDTL NUMBER	6.01917	41.07396
REYNOLDS NUMBER	40.61	66.56
NUSSELT NUMBER	6.4171	5.8259
HEAT TRNSFR COFF	128.6474	84.9689
PRSS DRP(IN H2O)	0.0563	3.8199
BEND FTR(IN H2O)	0.0005	0.0522
FLOW RT (LB/HR)	300.00	700.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.87343	0.39989

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	64.101
POWER (WATTS)	1185.861

SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1109
54 TE UNITS MODEL NO. CX952-70-31
WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579
COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	303.15	281.77
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	300.60	282.30
HT OUT OF FLD(W)	-1662.24	462.10
PLT-PLT LOSS (W)	4.19	4.19
PRANDTL NUMBER	6.34998	48.24938
REYNOLDS NUMBER	64.54	7.98
NUSSELT NUMBER	6.4945	5.0365
HEAT TRNSFR COEF	129.4079	73.7590
PRSS DRP(IN H2O)	0.0988	0.6412
HEND FTR(IN H2O)	0.0013	0.0011
FLOW RT (LB/HR)	500.00	100.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71188	0.95769

STEADY-STATE SYSTEM POWER CONDITIONS
VOLTAGE (VOLTS) 18.500
CURRENT (AMPS) 64.779
POWER (WATTS) 1198.414

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              SYSTEM PERFORMANCE DESCRIPTION      DATE 01/21/77  1240
           54 TE UNITS MODEL NO. CX952-70-31
   WIRED AS  18 PARALLEL SETS OF   3 UNITS IN SERIES

                  THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION
 HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)=  1.579
 COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02
  HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03
 COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)=  6.3,   6.3,  20.0

          T.E. MATERIAL       COMM       COMM
    COUPLE DISTRIBUTION=      70.00      31.00
   PELLET  WIDTH (INCH)=     0.0550     0.0850
   PELLET LENGTH (INCH)=     0.0630     0.1510
   STAGE AREA  (SQ INCH)=    1.4400     1.4400
   ALUMINA THKNS (INCH)=     0.0300     0.0300
   BUS-BAR THKNS (INCH)=     0.0150     0.0320

 EXCHANGER FACTOR          HOT       COLD
       FLUID TYPE         WATER      60%EG
   PLATE TEMP (K)        303.24     284.78
   INLET TEMP (K)        294.30     294.30
  OUTLET TEMP (K)        300.67     285.92
 HT OUT OF FLD(W)      -1678.76     486.11
 PLT-PLT LOSS (W)          3.61       3.61
   PRANDTL NUMBER       6.34558   45.50531
  REYNOLDS NUMBER         64.58      12.75
   NUSSELT NUMBER        6.4945     5.1113
 HEAT TRNSFR COEF      129.4178    74.7484
 PRSS DRP(IN H2O)        0.0988     0.9042
 BEND FTR(IN H2O)        0.0013     0.0024
  FLOW RT (LB/HR)        500.00     150.00
 EXCH WEIGHT (LB)         41.75      11.60
  FIN LENGTH (IN)        12.000     12.000
  LVR LENGTH (IN)        12.000     12.000
  FIN HEIGHT (IN)         1.205      0.510
  FIN THKNSS (IN)         0.015      0.015
   NUMBER OF FINS         32.00      32.00
      FIN EPSILON       0.71190    0.88083

  STEADY-STATE SYSTEM POWER CONDITIONS
        VOLTAGE (VOLTS)     18.500
         CURRENT (AMPS)     65.004
          POWER (WATTS)   1202.575
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SYSTEM PERFORMANCE DESCRIPTION   DATE 01/21/77 1109

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300   WEIGHT (GRAM)= 21.129   RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	303.32	286.28
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	300.72	287.88
HT OUT OF FLD(W)	-1692.93	497.42
PLT-PLT LOSS (W)	3.34	3.34
PRANDTL NUMBER	6.34126	44.10556
REYNOLDS NUMBER	64.62	17.59
NUSSELT NUMBER	6.4945	5.1848
HEAT TRNSFR COEF	129.4275	75.7625
PRSS DRP(IN H2O)	0.0987	1.1669
BEND FTR(IN H2O)	0.0013	0.0043
FLOW RT (LB/HR)	500.00	200.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71191	0.80061

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	65.100
POWER (WATTS)	1204.357

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1109

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	303.38	287.75
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	300.76	289.93
HT OUT OF FLD(W)	-1704.43	508.37
PLT-PLT LOSS (W)	5.06	3.06
PRANDTL NUMBER	6.53773	42.70318
REYNOLDS NUMBER	64.65	27.34
NUSSELT NUMBER	6.4945	5.3263
HEAT TRNSFR COEF	129.4354	77.7641
PRSS DRP(IN H2O)	0.0987	1.6939
BEND FTR(IN H2O)	0.0013	0.0096
FLOW RT (LB/HR)	500.00	300.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71192	0.66691

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	65.200
POWER (WATTS)	1206.208

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0450
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0500	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	303.44	288.95
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	300.80	291.64
HT OUT OF FLUID(W)	-1715.17	517.12
PLT-PLT LOSS (W)	2.83	2.83
PRANDTL NUMBER	6.33448	41.58694
REYNOLDS NUMBER	64.68	46.90
NUSSELT NUMBER	6.4945	5.5879
HEAT TRNSFR COFF	129.4428	81.5263
PRSS DRP(IN H2O)	1.0986	2.7545
BEND FTR(IN H2O)	0.0013	0.0266
FLOW RT (LB/HR)	500.00	500.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71194	0.49757

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS)	18.500
CURRENT (AMPS)	65.279
POWER (WATTS)	1207.660

SYSTEM PERFORMANCE DESCRIPTION DATE 01/21/77 1240

54 TE UNITS MODEL NO. CX952-70-31

WIRED AS 18 PARALLEL SETS OF 3 UNITS IN SERIES

THERMOELECTRIC DEVICE PHYSICAL DESCRIPTION

HEIGHT (INCH)= 0.4300 WEIGHT (GRAM)= 21.129 RESISTANCE (OHM)= 1.579

COLD M*CP PER TE DEVICE (WATT*SEC/C)= 0.55448E+02

HOT M*CP PER TE DEVICE (WATT*SEC/C)= 0.26973E+03

COLD,HOT,INTERSTAGE CONDUCTIVITY (WATT/SQ IN/C)= 6.3, 6.3, 20.0

T.E. MATERIAL	COMM	COMM
COUPLE DISTRIBUTION=	70.00	31.00
PELLET WIDTH (INCH)=	0.0550	0.0850
PELLET LENGTH (INCH)=	0.0630	0.1510
STAGE AREA (SQ INCH)=	1.4400	1.4400
ALUMINA THKNS (INCH)=	0.0300	0.0300
BUS-BAR THKNS (INCH)=	0.0150	0.0320

EXCHANGER FACTOR	HOT	COLD
FLUID TYPE	WATER	60%EG
PLATE TEMP (K)	303.47	289.52
INLET TEMP (K)	294.30	294.30
OUTLET TEMP (K)	300.83	292.39
HT OUT OF FLD(W)	-1720.81	521.18
PLT-PLT LOSS (W)	2.73	2.73
PRANDTL NUMBER	6.33276	41.11147
REYNOLDS NUMBER	64.70	66.49
NUSSELT NUMBER	6.4945	5.8258
HEAT TRNSFR COEF	129.4467	84.9690
PRSS DRP(IN H2O)	0.0986	3.8236
BEND FTR(IN H2O)	0.0013	0.0522
FLOW RT (LB/HR)	500.00	700.00
EXCH WEIGHT (LB)	41.75	11.60
FIN LENGTH (IN)	12.000	12.000
LVR LENGTH (IN)	12.000	12.000
FIN HEIGHT (IN)	1.205	0.510
FIN THKNSS (IN)	0.015	0.015
NUMBER OF FINS	32.00	32.00
FIN EPSILON	0.71194	0.39990

STEADY-STATE SYSTEM POWER CONDITIONS

VOLTAGE (VOLTS) 18.500

CURRENT (AMPS) 65.314

POWER (WATTS) 1208.311

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